AD NUMBER
ADB360405
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; JAN 2010. Other requests shall be referred to 711th Human Performance Wing/RHPA, 2800 Q Street, Bldg 824, Wright-Patterson AFB, OH 45433-7947.**
AUTHORITY
711 HPW/OMCA AFRL memo dtd 23 Mar 2015

AFRL-RH-WP-TR-2010-0083

SEAT INTERFACES FOR AIRCREW PERFORMANCE AND SAFETY

Nathan L. Wright
Joseph A. Pellettiere
Scott M. Fleming
Suzanne D. Smith
Jennifer G. Jurcsisn

Biosciences and Protection Division
Biomechanics Branch

JANUARY 2010
Final Report

Distribution A: Approved for public release; distribution unlimited.

AIR FORCE RESEARCH LABORATORY
711TH HUMAN PERFORMANCE WING,
HUMAN EFFECTIVENESS DIRECTORATE,
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE

NOTICE AND SIGNATURE PAGE

AFRL-RH-WP-TR-2010-0083 HAS BEEN REVIEWED AND IS APPROVED FOR PUBLICATION IN ACCORDANCE WITH ASSIGNED DISTRIBUTION STATEMENT.

//signed//
JOHN BUHRMAN
Work Unit Manager
Applied Neuroscience Branch

//signed//
SCOTT M. GALSTER
Chief, Applied Neuroscience Branch
Warfighter Interface Division

//signed//
WILLIAM E. RUSSELL
Chief, Warfighter Interface Division
711th Human Performance Wing
Air Force Research Laboratory

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
01-01-2010	Final	15 June 2005- 15 December 2009

4. TITLE AND SUBTITLE
Seat Interfaces for Aircrew Performance and Safety

5a. CONTRACT NUMBER IN-HOUSE
5b. GRANT NUMBER N/A
5c. PROGRAM ELEMENT NUMBER 62202F

6. AUTHOR(S)
Nathan L. Wright
Joseph A. Pellettiere
Scott M. Fleming
Suzanne D. Smith
Jennifer G. Jurcsisn

5d. PROJECT NUMBER 2830
5e. TASK NUMBER HP
5f. WORK UNIT NUMBER 2830HP01

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Materiel Command
Air Force Research Laboratory
711th Human Performance Wing
Human Effectiveness Directorate
Biosciences and Protection Division
Biomechanics Branch
Wright-Patterson AFB OH 45433-7947

10. SPONSOR/MONITOR'S ACRONYM(S)
711 HPW/RHPA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
AFRL-RH-WP-TR-2010-0083

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A: Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
88ABW Cleared 03/13/2015; 88ABW-2015-1053.

14. ABSTRACT
Advanced prototype seat cushions were developed and tested to a draft specification to deliver increased comfort and performance to Airmen in confined environments while maintaining safety. Two prototype cushions were chosen as viable replacements to the ACES II cushion: an active air bladder cushion developed by Goodrich AIP for long duration missions and a contoured, rate-sensitive foam cushion developed by Oregon Aero. Research efforts included multi-hour comfort testing of cushions, environmental, anthropometric accommodation, impact testing to ensure safety, ejection sled testing, modeling, and developmental flight testing.

15. SUBJECT TERMS
Seat cushion, air bladder, human performance, blood flow, comfort

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			John Buhrman (Scott Fleming)
U	U	U	SAR	278	**19b. TELEPHONE NUMBER** *(include area code)*

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

THIS PAGE IS INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

The work reported was part of an AFRL 6.3 Technology Demonstration program, "Seat Interfaces for Aircrew Performance and Safety". The program was sponsored by the Vulnerability Analysis Branch of the 711th Human Performance Wing and was managed by Mr. Scott Fleming and Dr. Joseph Pellettiere.

Special thanks to the following organizations that were instrumental in the success of this program:

- 711 HPW/RHPA, General Dynamics and InfoSciTex Corporation- testing support for VDT, comfort, anthropometry testing and statistical support (Chuck Goodyear).
- Wright State University -Department of Biomedical, Industrial & Human Factors Engineering- comfort testing support.
- Goodrich AIP and EASE Seating Systems – for providing prototype seat cushions
- Oregon Aero– for providing prototype seat cushions
- Edwards AF Flight Test Center and Whiteman AFB- operational flight testing
- 702 AESG (B-2 SPO), 642 CBSG (Life Support SPO and ACC/A3- approval for flight testing.

SUMMARY

Advanced prototype seat cushions were developed and tested to a draft specification to deliver increased comfort and performance to Airmen in confined environments while maintaining safety. Research efforts included multi-hour comfort testing of cushions, environmental testing, anthropometric accommodation, impact tests on AFRL's Vertical Deceleration Tower to ensure safety, ejection sled testing, and modeling. Two prototype cushions were chosen as viable replacements to the ACES II cushion: an active air bladder cushion developed by EASE Seating Systems, a subcontractor to Goodrich AIP, and a contoured, rate-sensitive foam cushion developed by Oregon Aero.

1.0 INTRODUCTION

Recent combat missions have reached more than forty hours in length, highlighting the importance of improving the seat interfaces for aircrew. Seat interface improvements are critical to enhance physical endurance and combat effectiveness of aircrew. Long-term sitting comfort may be enhanced by a new or improved seat cushion. However, some seat cushions have been shown to amplify the acceleration transmitted to the torso of the aircrew member if they have not been designed properly (Cohen, 1998). Any item introduced to an ejection seat and located between the seat pan and the gluteal region of the pilot must not compromise the existing risk of spinal injury which is limited by the human tolerance to the fracture of the lumbar vertebra. As more resources are applied to improving seat cushion comfort, the performance of a cushion for the prevention and reduction of spinal injuries (the safety performance) should not be compromised. The safety performance of a cushion can be measured by spinal injury criteria such as Dynamic Response Index (DRI) or directly by certain occupant response characteristics, such as the peak lumbar load and the peak chest acceleration (Hearon & Brinkley, 1986 and Perry, 1997). The evaluation of the safety performance of ejection seat cushions is conventionally performed using impact tests. A number of Vertical Deceleration Tower (VDT) test studies have been performed at the Air Force Research Laboratory (AFRL) over the past 4 decades to evaluate several types of ejection seat cushions, including certain designs with comfort improvement (Cohen, 1998, VanIngen-Dunn & Richards, 1992; Severance, 1997; Ferguson-Pell & Cardi, 1992a & 1992b; Desjardins & Laananen, 1979; and Shields & Cook, 1992). The basic mechanical properties of the materials used in the design of seat cushions can be directly measured (Pint, Pellettiere & Coate, 2000). These mechanical properties can then be used to characterize how cushions built from basic materials would perform during an actual ejection (Cheng, Rizer & Pellettiere, 2002a). The impact tests provide a wealth of information and data that can be coupled with analysis methods such as optimization (Cheng & Pellettiere, 2005 and Cheng & Pellettiere, 2003). The analytical methods provide a means for objectively evaluating and ranking various cushions according to their ability to absorb energy and reduction specific safety metrics (Cheng & Pellettiere, 2004a). All of this culminating in a robust process for designing and developing ejection seat cushions (Pellettiere & Cheng, 2004).

Beyond safety of cushions, the comfort characteristics of existing ejection seat cushions in Air Force aircraft are not suitable for extended missions. Shortcomings of existing cushions have been documented by researchers (Brinkley, Perry, Orzech & Salerno, 1993; Cohen, 1998; Hearon & Brinkley, 1986; VanIngen-Dunn & Richards, 1992; and Severance, 1997) and interviews conducted with pilots and flight surgeons (Pint, 1999). The most common symptoms were soreness, tingling, numbness and fatigue. The source of discomfort during extended missions has several causes. The materials used in ejection seat cushions are not selected based on their comfort properties; rather, they are selected for their performance in limiting spinal injuries during ejection. Cockpit space restrictions associated with most ejection seat equipped aircraft severely restrict the seat occupant's ability to reposition during flight. Ejection seat dimensions and contours are fixed, causing accommodation problems, especially for large and small occupants. Previous research has shown that all of these problems can be addressed (Cohen, 1998; VanIngen-Dunn & Richards, 1992; Severance, 1997; Shields & Cook, 1992; Henderson, Price, Brandstater, & Mandac, 1994; and Bennett, 1984). However, completely

eliminating all occupant discomfort would likely require an entire seat system redesign or a limit in the duration of the mission. This leaves the seat cushion itself as the most viable option for modification to improve the physical endurance of pilots.

A feasible component of the seat system to which cost-effective modifications can be made to enhance aircrew comfort is the ejection seat cushion. Recent studies have shown that cushions made from various densities of Confor™ provide superior impact protection and improved occupant comfort (Cohen, 1998; Hearon & Brinkley, 1986; Perry, 1997; and Perry, Nguyen, & Pint, 2000) compared to foam rubber or polyurethane combinations. In fact, a replacement cushion was approved for use in the B-2 and other ACESII configurations based upon impact testing and an evaluation of cushions with different densities of Confor™ and various surface contours. However, in a recent evaluation of the replacement B-2 cushions, it was determined that no single cushion could be designed to accommodate the entire anthropometric range. It was recommended that individual cushions be fitted for each pilot (Cohen, 1998). Another technique that has been used extensively for wheelchair users is active stimulation incorporated within the cushion using pulsation or vibration devices. A qualification study was performed on a pulsating seat cushion and adjustable lumbar pad combination for US Navy aircraft. The results showed no increased injury risk, but also highlighted the need for further research in this area (Cantor, 1974). The Air Force Reasearch Laboratory (AFRL) has also investigated the application of dynamic airbladders to decrease discomfort and improve physical endurance of seated occupants (Pellettiere, Parakkat, Reynolds, Sasidharan & El-Zogbil, 2006 and Parakkat, Pellettiere, Reynolds, Sasidharan & El-Zogbi, 2006) with some promising results.

Seat cushion comfort measurements have historically consisted of subjective methods. There are some shortcomings of using only subjective methods for this purpose. First, design flaws are only accurately identified after prototypes have been built and tested. Second, a large number of subjects with varied anthropometric characteristics are required to obtain meaningful results due to varying opinions and preferences (Cohen, 1998). Finally, the subjective results may be influenced by outside factors such as emotion, fatigue, or incentives. Some subjective methods are useful for identifying trends or to correlate other objective data. Tools such as surveys can also be used to gather data when other objective methods are not available or feasible.

As mentioned, in the past, seat cushions were selected based upon their safety properties, and studies have been conducted on how to quantify comfort for seat systems (Stubbs, Pellettiere & Pint, 2005). However, these two properties should not be considered independently (Cheng & Pellettiere, 2005). Comfort and safety metrics can be considered simultaneously and one traded for another. A different option would be to set the baseline safety requirements as a hard metric, then ensure any candidate cushions met or exceed this metric and then conduct the optimization on those candidates and select for their ability to minimize physical fatigue.

Taking these two goals into consideration, The AFRL began a program to design and develop different seat cushions based on objective testing to provide pilots with a more comfortable, yet safe, alternative to the currently used ejection seat cushion. Based on the results of the program, a draft seat cushion specification was written to capture the technical characteristics of the developed cushion as well as any future cushion. The resulting draft seat cushion is included in Appendix A. The F-16 ejection seat (ACES II) was considered a baseline as the accommodation

is most restrictive compared with other aircraft. Several prototype and commercial cushions were considered at the start of the program based on both comfort and safety. After these cushions were tested on AFRL's Vertical Deceleration Tower (VDT) and evaluated for comfort during long-duration studies, the cushions were down selected to two potential options. By the end of the program, two cushions were chosen as comfortable and safe: the Oregon Aero contoured rate-sensitive foam cushion and the Goodrich Aircraft Interior Products (AIP) active air bladder cushion. As a variation of the Oregon Aero cushion has already been operationally used, an effort to approve the Goodrich AIP cushion for flight was accomplished through environmental testing, sled testing, and developmental flight testing.

The Goodrich AIP active cushion (Figure 1) cycles air in-and-out of air bladders within the seat cushion to promote blood flow into pilot buttocks, legs, and feet during long duration flights. The cushion incorporates a small motor and battery pack to pump air into the bladders. The active cushion requires no user intervention as it has a sensor to determine when a pilot is seated and the system needs to start operating. However, the cushion has an on/off switch for the cushion during critical phases of flight to avoid distractions and for storage to prevent the unintended startup and drain of the batteries. During ejection, the air in the cushion is displaced laterally to decrease the probability of interference to the pilot.

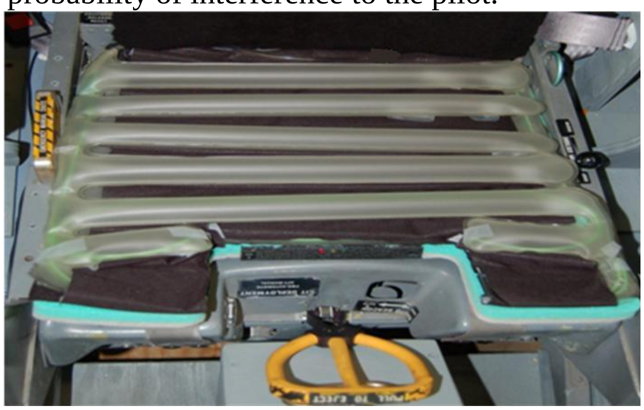


Figure 1. Goodrich AIP Air Bladder Cushion (Cover Removed)

The contoured seat cushion was developed by Oregon Aero (Figure 2) and uses a thick block of rate-sensitive foam to increase the comfort of the cushion.

Figure 2. Oregon Aero Contoured Foam Cushion (Cover Removed)

A series of tests on the prototype cushions were accomplished. These tests included:

- Comfort: Evaluates the cushions ability to prevent discomfort over extended durations
- Simulator: Evaluates that the cushion does not interfere with flight operations or distract the pilot
- Modeling: Creates development platform for simulations on performance and safety
- Cockpit Accommodation: Determines if cushion interferes in the cockpit for some anthropometries
- Vertical Impact: Evaluates that the safety criteria are met in a component test
- Vibration: Determines if there are any new effects induced as a result of the cushion
- Sled Testing: Evaluates that the safety criteria are met in a rocket sled ejection test
- Flight Testing: Operational testing for pilot acceptance and verification of flight operations

Testing was accomplished in accordance with a draft seat cushion performance specification (Appendix A) drafted by both the 648 AESS SPO at Brooks City Base, TX and 711HPW/RHPA. Testing throughout the program was conducted as a means to validating the spec and changes were made where appropriate. The starting point for the specification was existing documents on other seat programs including the ACESII and the Fixed Aircrew Seat Standardization (FASS) program. The as written spec was developed after consultation with the Army, Navy, and FAA and progress was vetted through the Aircrew Safety Standardization Board.

2.0 METHODS, ASSUMPTION AND PROCEDURES

2.1 Comfort Testing

A series of long-duration comfort evaluations were conducted using human volunteer subjects on a variety of cushions. Little data exists correlating subjective discomfort and objective measurements. Through previous AFRL testing (Pint, Pellettiere & Nguyen, 2002; Pellettiere & Cheng, 2004; Stubbs et al., 2005; and Parakkat et al., 2006), testing methodologies to record seat cushion pressure measurements were developed and correlation between subjective and quantitative data were be established. Phase I consisted of an 8-
test time and phase II consisted of a 4-hour test time. Generalities of the test methods will be discussed followed by specifics for each of the two phases. Subjects completed the testing in each phase over a period of four separate days in a sequential counter balanced order. During each test session, subjects were seated in an F-16 ejection seat mockup with their feet resting on a foot pedestal. While seated, non-invasive measures were recorded including physical, physiological, and cognitive parameters. The physical parameters recorded were the pressures and contact areas elicited at the subject-cushion interface, which were collected using a thin film pressure mat. The physiological parameters recorded were the regional blood oxygen saturation in the lower extremities. The cognitive parameter recorded was the performance levels on a multi-attribute task battery. In addition to the objective parameters, subjective comfort evaluations were collected at 2-hour intervals during the test session and upon completion of the session. By measuring objective and subjective parameters, existing correlations in the two data types could be identified.

Tests were conducted at either the Biomedical Engineering Department of Wright State University or in the Biomechanics Branch of the Air Force Research Laboratory. Prior to data

collection, the study plan was approved by both the Wright State University and the Wright-Patterson AFB Wright Site Institutional Review Boards (IRB). A series of long-duration comfort evaluations were conducted using human volunteer subjects on a variety of cushions. Phase I consisted of an 8-hour test time and phase II consisted of a 4-hour test time. Generalities of the test methods will be discussed followed by specifics for each of the two phases. Subjects completed the testing in each phase over a period of four separate days in a sequential counter balanced order. During each test session, subjects were seated in an F-16 ejection seat mockup with their feet resting on a foot pedestal. While seated, non-invasive measures were recorded including physical, physiological, and cognitive parameters. The physical parameters recorded were the pressures and contact areas elicited at the subject-cushion interface, which were collected using a thin film pressure mat. The physiological parameters recorded were the regional blood oxygen saturation in the lower extremities. The cognitive parameter recorded was the performance levels on a multi-attribute task battery. In addition to the objective parameters, subject comfort evaluations were collected at 2-hour intervals during the test session and upon completion of the session. By measuring objective and subjective parameters, existing correlations in the two data types could be identified.

The subject-cushion interface pressure and contact area measurements of the seated surface area (buttocks, thighs, and back) were collected before each test session commenced using an XSENSOR™ X2 Pressure Imaging System (XSENSOR Technology Corporation, Calgary, Canada). The pressure mat was placed on top of the seat pan and against the back cushion. Subjects sat atop the pressure mat for 6 minutes for the static cushions and 10 minutes for the dynamic cushions. Previous studies (Stubbs et al., 2005) have indicated that a 6 minute settling period is sufficient time to allow the occupant and cushion to reach a steady state with no additional significant pressure fluctuations for static cushions. A pressure snapshot was recorded at the end of the 6 minute period for the static cushions. Because settling will not occur due to dynamics, a 10-minute pressure profile was recorded to capture the changes in pressure and contact area for a 10-minute cycle time of dynamic cushions. This extended duration recorded was successfully used in a previous study with dynamic cushions (Pellettiere et al., 2006).

Regional blood oxygen saturation in the lower extremities was measured with either an INVOS® Near Infrared Spectroscopy Oximeter (Somanetics Corporation, Troy, MI) or a Bioelectrical Impedance Analysis (RJL, Clinton Township, MI). When using the INVOS® a Soma Sensor was placed on the bulk of either the right or left calf muscle depending on which of the two ejection seat stations the subject was seated. The SomaSensor was a flexible adhesive sensor 1” x 4” that contained no hazard to the subject. The INVOS Oximeter collected a steady stream of blood oxygenation data over the entire test session. When using the BIA, the device was also fitted over the right calf muscle of the subject. BIA can show relative blood volume shifts due to changes in the electrical properties of a body segment. Resistance and reactance data was collected to estimate blood volume changes. The Quantum-II Desktop system collected continuous data of resistance and reactance in the leg, which can then be correlated to blood volume values, from the electrodes over the 4-hour trial period.

At the start of each session in Phase I and every two hours thereafter, the subject completed a cognitive task battery (Synthetic Work for Windows or SynWin). Subjects were trained for up to a total of eight hours (four sessions of 2 hours each) to become familiarized with the testing. A

subject was considered adequately trained on the SynWin task performance software when they reached an improvement plateau (i.e., their performance on the task did not improve no matter how many times they performed the task). No cognitive task battery was administered during Phase II.

During initial training several anthropometric measurements were collected: height, weight, sitting height, hip-breadth sitting, and buttock-knee length. Once subjects were trained, they were cleared to complete the cushion seat tests. The subjects were asked to minimize leg and foot movement. Subjects were provided with an aircrew-type urine collection device for use as needed. All subjects provided an informed consent and the procedures followed an Institutional Review Board (IRB) approved protocol.

Every 30 minutes during the Phase I 8-hour tests, the subject performed isometric exercises (foot pumps, ankle rotations, and knee lifts) and leg stretching exercises. During the Phase II 4-hour tests, subjects walked for 5 minutes before each 4-hour period in order to reverse any lower-extremity blood pooling. Every 60 minutes during the 4-hour tests, the subject was asked to perform a “check six” maneuver, isometric exercises, and leg stretching exercises.

At the beginning of each test session, the subject completed an electronic comfort survey (TNO Defence, Security and Safety (Oudenhuijzen, 2007)). At the end of each test session, the subject completed an End-of-Day comfort survey. For the Phase I 8-hour tests, the subjects then completed a comfort survey every two hours. For the Phase II 4-hour tests, the subjects completed a comfort survey every hour.

Phase I testing was conducted over an eight hour time period and the methods used were developed based upon experience from previous studies (Stubbs et al., 2005 and Parakkat et al., 2006). A different study analyzed the time effects during these long-duration comfort studies and determined that the same significance can be achieved after a test period of six hours and possibly even four hours depending on the number of subjects and variability in the data (Pellettiere et al., 2006). Because subject recruitment and scheduling were difficult in Phase I and the time constraints on completing Phase II were short, it was decided to shorten the testing time to four hours. This would allow multiple tests to be conducted on a single day and provide flexibility for the subjects.

2.1.1 Test Cells

For the Phase I 8-hour comfort study, four cushions were used:

1. Cushion A – Operational ACES II F-16 cushion: Currently approved and standard ACESS II cushion composed of Confor™ C-47 and Polyethylene with a sheepskin cover
2. Cushion B – Sereflex cushion- Bingham fluid cushion: Non-Newtonion fluid in 4” square pockets separated by a layer of Confor™ C-45 with a fabric cover
3. Cushion C – Goodrich Air Bladder Cushion Manual Inflation/Deflation: Modified version of Cushion A with a set of inflatable bladders on the foam, but under the sheepskin, bladders were manually inflated via a pressure bulb
4. Cushion D – Goodrich Air Bladder Cushion Automatic Inflation/Deflation Modified version of Cushion A with a set of inflatable bladders on the foam, but under the

sheepskin, bladders were automatically inflated via a batter operated pump and control module

For the Phase II 4-hour study, five combinations of cushions were used.

1. Cushion A- Operational ACES II F-16 cushion: Currently approved and standard ACESS II cushion composed of Confor™ C-47 and Polyethylene with a sheepskin cover
2. Cushion B- Goodrich Air Bladder Cushion Automatic Inflation/Deflation w/C45 foam: Similar to cushion A, but with Confor™ C-45 foam and a set of inflatable bladders on the foam, but under the sheepskin, bladders were automatically inflated via a batter operated pump and control module
3. Cushion C- Goodrich Air Bladder Cushion Automatic Inflation/Deflation w/C47 foam: Similar to Cushion A with a set of inflatable bladders on the foam, but under the sheepskin, bladders were automatically inflated via a batter operated pump and control module
4. Cushion D- Oregon Aero ICT Air Bladder cushion: Sculpted block of Confor™ C-47 foam with a thick fabric cover with a set of air bladders on top of the foam but under the cover, bladders were automatically inflated via a battery operated pump and control module
5. Cushion E- Oregon Aero EPCI contoured foam cushion: Sculpted block of Confor™ C-47 foam with a thick fabric cover

For both phases of testing, the order of cushions used was varied between subjects using a counter balanced sequential testing sequence

2.1.2 Subjects

For the Phase I 8-hour study, the subjects were recruited by Wright State University (WSU). Each subject completed a "Medical Prescreen Questionnaire" that was reviewed by the medical monitor to screen any pre-existing risk factors that increase their risk for deep venous thrombosis. The twenty-four (12 males and 12 females) test subjects took part in this study. The subjects had similar anthropometries to the flying population (Figures 3 and 4) with the males ranging in height from 66 to 72 inches and in weight from 140 to 185 pounds; females ranged in height from 63 to 72 inches and in weight from 125 to 175 pounds. Subjects were instructed to wear comfortable clothing.

For the Phase II 4-hour study, subjects were recruited from the surrounding community and college campuses. Screening was the same as the 8-hour study. Thirty (15 male and 15 female) subjects took part in this study. The subjects had similar anthropometries to the flying population (Figures 5 and 6) with the males ranging in height from 65 to 74 inches and in weight from 146 to 198 pounds; females ranged in height from 62 to 72 inches and in weight from 119 to 155 pounds. Subjects were dressed in a military flight suit, CWU-27/P.

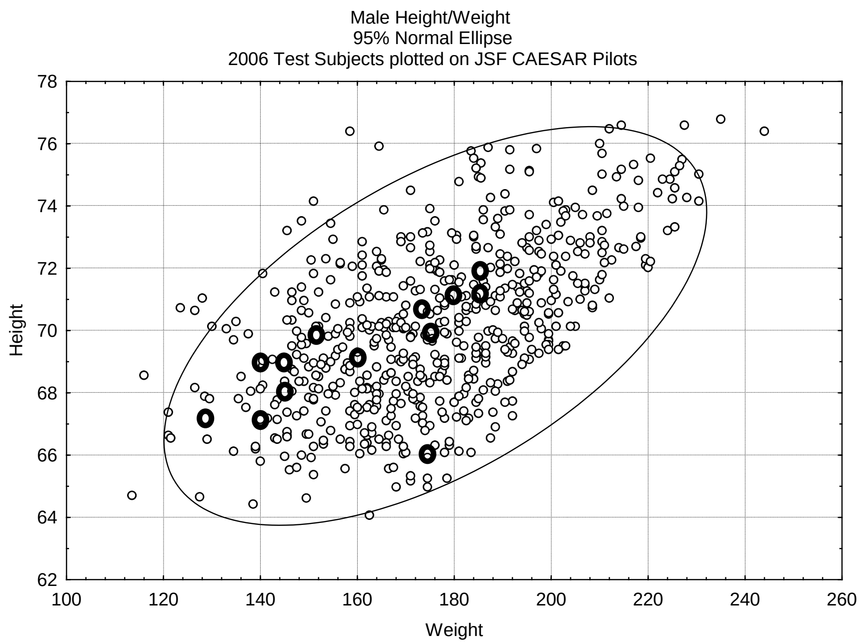


Figure 3. Male Subject Size for 8-hour Comfort Study Compared to USAF Pilot Size

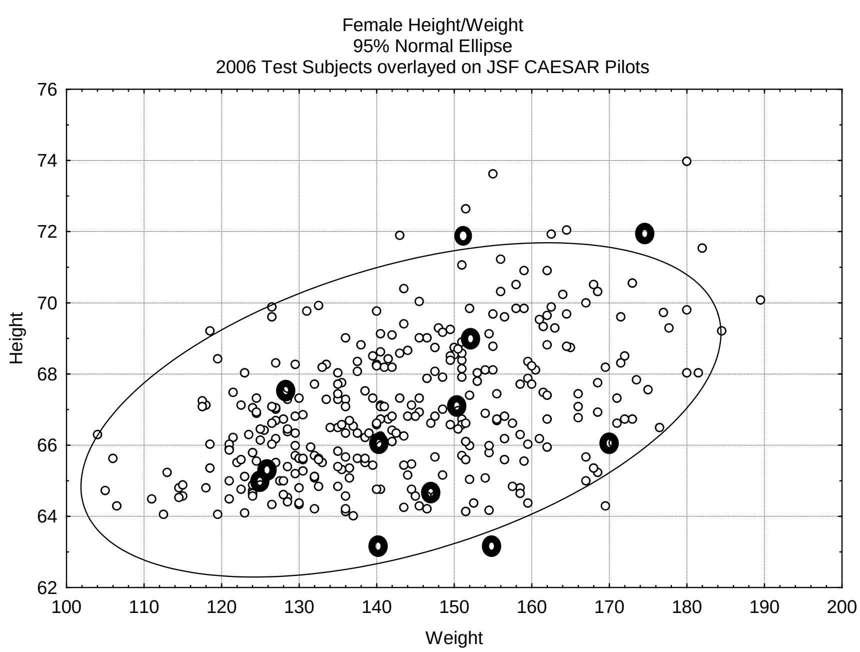


Figure 4. Female Subject Size for 8-hour Comfort Study Compared to USAF Pilot Size

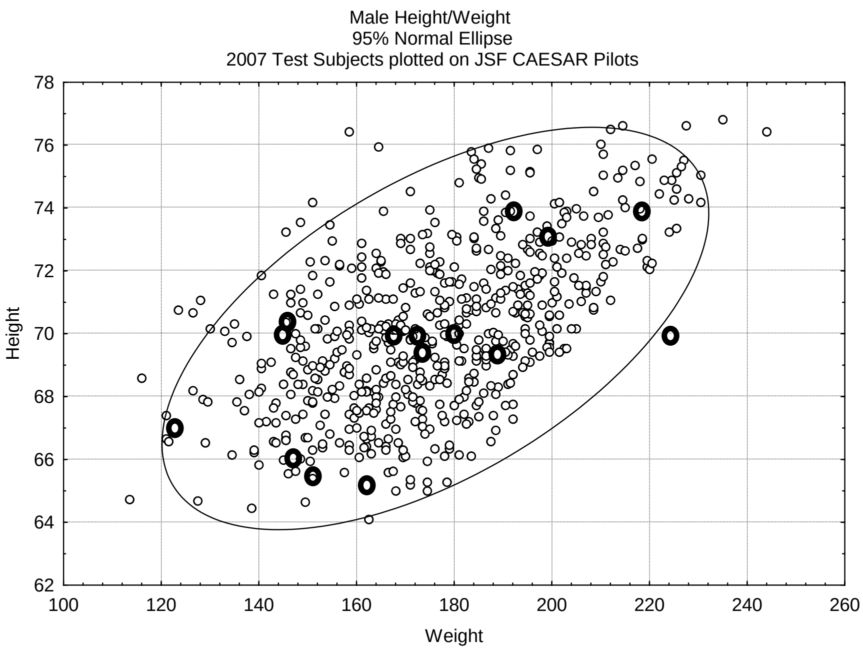


Figure 5. Male Subject Size for 4-hour Comfort Study Compared to USAF Pilot Size

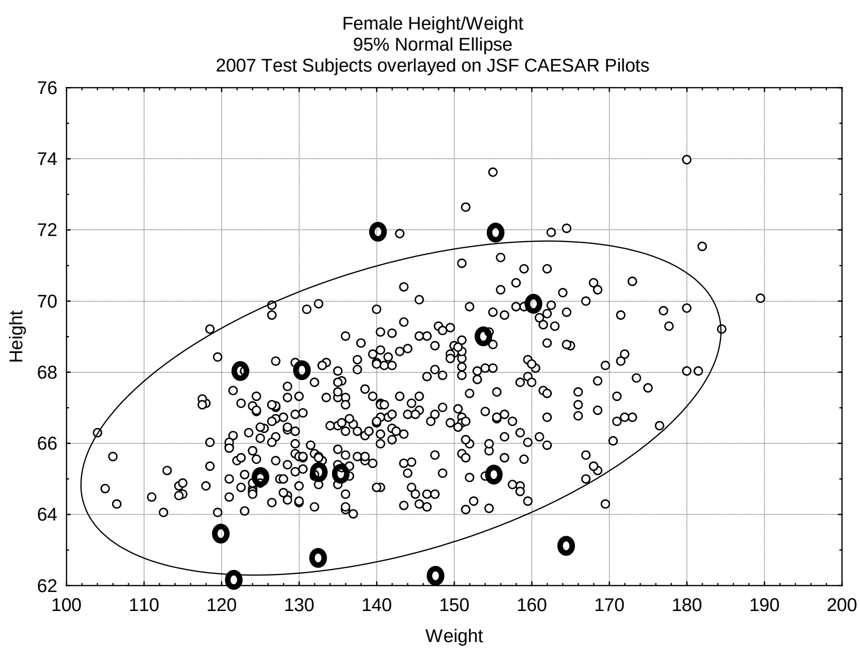


Figure 6. Female Subject Size for 4-hour Comfort Study Compared to USAF Pilot Size

2.1.3 Test Equipment

The 8-hour study was held within the WSU engineering laboratories. All cushions and supports were placed on the F-16 seat mockup to obtain pressure and contact area measurements. The seat was mounted such that the rail angle is 34.4° aft of vertical and the seat pan is inclined 4° from the horizontal that is consistent with an F-16 seat configuration (Figure 7). The cockpit

mockup also included a laptop computer, a monitor, a keyboard, and a mouse. The keyboard and the mouse tray were adjusted to each subject.

Subjects were required to remain seated in the mockup for the entire 8-hour session with a lap belt fastened. The seat configuration for the 4-hour study was consistent with the 8-hour study and was conducted at Wright-Patterson AFB.

Figure 7. Comfort test setup

2.1.4 Data Collection and Analysis

Data collected consisted of task performance, subjective comfort responses, pressure mapping, oxygen saturation for the 8-hour test, and bioelectrical impedance for the 4-hour tests. Calf circumference was recorded at the start of the 8-hour test. All subjects completed all required tests on the cushions. The order of seat cushions tested was counterbalanced across subjects.

2.1.4.1 Cognitive Task

At the start of each Phase I test session and every two hours thereafter, subjects completed a 5-minute cognitive task battery as a measure of performance throughout the 8-hour session. SynWin, created by Activity Research Services, was used to obtain objective performance data. The SynWin analysis provided a benchmark set of tasks for use in a wide range of laboratory studies of operator performance and workload and is similar to the Multi-Attribute Task Battery (MATB) (Caldwell, Ramspott & Gardner, 1998; Carmody, 1994; LeDuc & Caldwell, 1998; and Caldwell, Smythe, Hall & Norman, 1999). The software incorporates tasks analogous to activities that aircraft crewmembers perform in flight, while providing a high degree of experimenter control, performance data on each subtask, and freedom to use non-pilot test subjects. The SynWin primary display is composed of four separate task areas, or windows, comprising the memory, arithmetic, visual monitoring, and auditory monitoring tasks (Figure 8). The program reports a composite score and individual task scores for each 5-minute test. Events presented to the subject are controlled by command-line switches, which can be easily edited by the researcher to manipulate task loading (Bennett, 1984; Arnegard, 1991; and Arnegard & Comstock, 1991). Subjects were trained on SynWin until their scores reached a plateau and stabilized prior to starting their first 8-hour test session. The Warfighter Fatigue

Countermeasures Branch (711HPW/RHPM) at Brooks City-Base, TX, has successfully used SynWin to evaluate human performance in numerous research programs.

No cognitive task analysis was used during the Phase II 4-hour study.

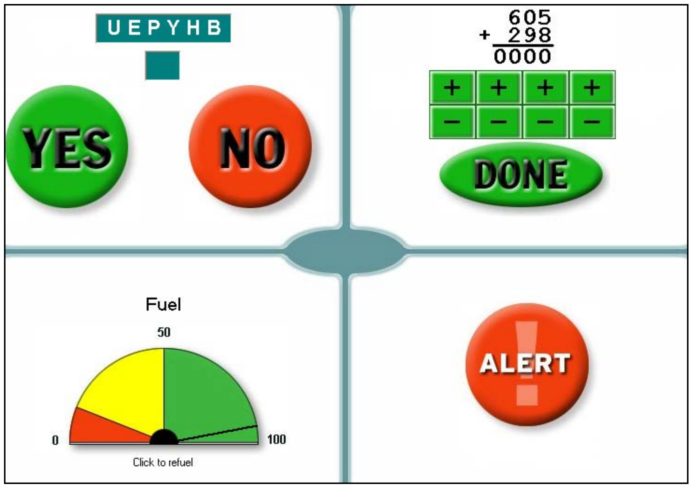


Figure 8. The Four Tasks Comprising the SynWin Task Battery

2.1.4.2 Comfort Survey.

A comfort survey designed by TNO Defence, Security and Safety (Oudenhuijzen, 2007) was used to assess subjective comfort and give an indication of which cushions the subjects preferred. The survey included three parts: the overall physical condition rating (PCR), the local perceived discomfort (LPD) for various body parts (Figure 9), and seat ratings. The survey was completed using the computer at selected intervals in the test session. The PCR consisted of a 10-point scale ranging from 1 (bad) to 10 (great).

The LPD rating used a 12-point scale ranging from 0 (no discomfort) to 11 (maximum discomfort). The results of the LPD rating were combined for several areas. The neck consisted of areas P, Q, R, S, and T. The back combined the areas A, B, C, and D to L. The arms and shoulders included areas AA-KK, G, H, O, and M. The buttocks included areas LL and SS. The legs combined the areas of the upper legs (MM and TT) to the feet (ZZ, RR). The various body areas are depicted in Figure 9.

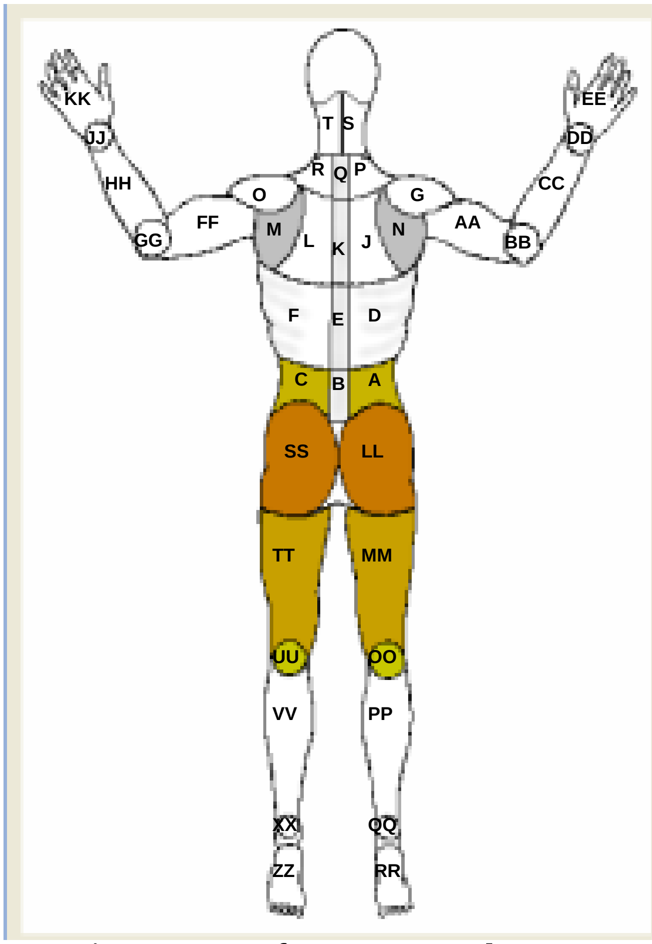


Figure 9. Comfort Survey Body Parts

For the seat ratings, the subjects rated the amount of seat support for the body parts on a 7-point scale ranging from -3 (not supported properly), 0 (proper support), to +3 (too much support). The subjects also rated the seat comfort for the same body parts on a scale from 1 (bad) to 5 (good). The seat firmness was rated on a 7-point scale ranging from -3 (too weak), 0 (OK), to +3 (too firm). The overall comfort was rated between 1 (uncomfortable) to 5 (comfortable).

2.1.4.3 Pressure Measurement.

For both the Phase I 8-hour and the Phase II 4-hour studies, pressure measurements were obtained using the XSENSOR™ X2 Pressure Mapping System. The system consisted of two thin mats, each containing a 36 x 36 array of sensors, a data interface cable, a data acquisition module, and PC software for data analysis (Figure 10). The sensor mats are extremely thin (0.1 mm) and pliable, enclosed in a nylon covering, and conform to the shape of any surface on which they are placed. The sensor mats were placed on top of the seat and back cushions and the subjects sat on top of the sensor mat. Pressure measurement systems such as this have been used extensively in the past for medical, automotive, and manufacturing pressure evaluations (Ferguson-Pell & Cardi, 1992). The XSENSOR™ software interface is highly user-configurable and allows for recording data over a span of time or as a still frame snapshot in time. Subject pressure snapshots were collected at the beginning of each test session following a

6-minute settling period for the static cushions. For the dynamic cushions, a time history of the pressure and contact area distribution was collected for a 10 minute cycle of inflation and deflation.

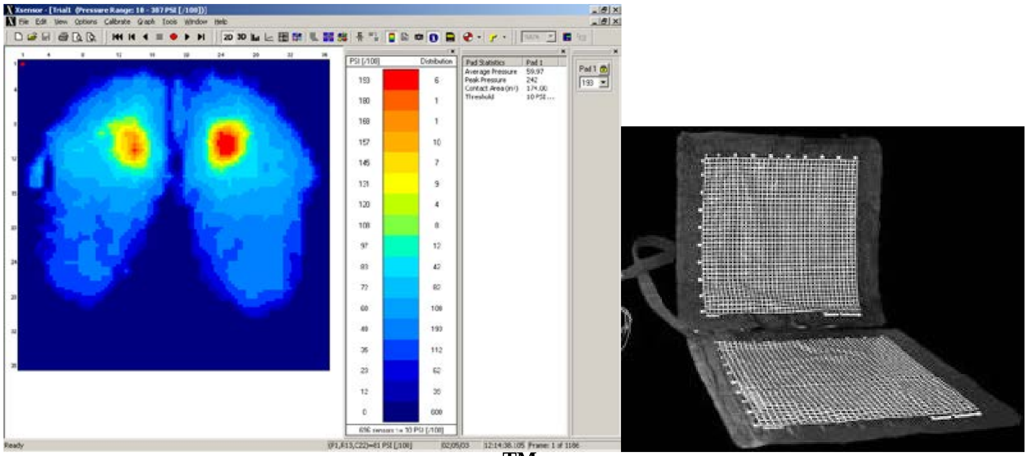


Figure 10. XSENSOR^{TM} Pressure Mat System

2.1.4.4 Oxygen Saturation Measurement

For the 8-hour study, measurement of oxygen saturation of the tissues below the buttocks region was critical in objectively measuring the comfort and tolerance relationship of the subject. The Somanetics INVOS NIRS Oximeter was used to collect oxygen saturation and blood volume data. The sensor was placed on the bulk of the calf muscle. Data was collected and stored in real time at a rate of approximately 10 samples per minute.

2.1.4.5 Bioimpedance Analysis (BIA)

For the 4-hour study, an RJL Quantum-II Desktop System (RJL, Clinton Township, MI) was used to record the resistance and reactance within the lower leg to determine blood volume changes. The Quantum-II Desktop System consists of a keyboard and hardware accessories (electrodes, cables, etc.), and interfaces with a desktop computer via software. 4 band electrodes are placed on the segment of interest (Figure 11).

Figure 11. BIA electrode placement

The BIA collected represents a series model of resistance and the reactance. The parallel model of resistance and reactance is a better equivalent to the biological circuit network and is how capacitance must be calculated. The following equations were used to calculate the capacitance from the series data collected.

$$\text{Parallel Reactance} = \text{Reactance} + (\text{Resistance}^2/\text{Reactance}) \quad (1)$$
$$\text{Capacitance (Pf)} = (1*10^{12}) / (2*\pi*50000*\text{Parallel Reactance}) \quad (2)$$

2.2 Simulator Testing

The operational ACES II, Goodrich Air Bladder, and Oregon Aero contoured cushions were installed into simulators in the Air Vehicles Directorate of AFRL (AFRL/RB) to get feedback from eleven pilots during 1-hour simulator flights. The focus of this study was to determine if either of the prototype cushions had a negative effect on the pilot's performance. It was determined that the cushions were not statistically different from one another with respect to the effect on the pilot's performance during a series of approaches and landings over the course of one hour in the simulator.

Goodrich Air Bladder prototype cushions were put in B-2 simulators at Whiteman AFB, MO during a 24-hour simulation flight. The pilots were instructed on their use and asked to perform their missions as they normally would. Following the simulations, they were provided a short questionnaire. Four pilots used the cushions and all four provided positive feedback on the performance of the air bladder cushions.

2.3 Modeling

Modeling and Simulation (M&S) can be used to augment the availability of data for both the safety performance and comfort aspects for the design of seating systems. The use of M&S to design seat cushions, taking the safety performance into consideration, has been well documented (Cheng, Rizer & Pelletiere, 2003; Cheng et al., 2002b; Pellettiere & Cheng, 2004). This modeling process should follow a rigorous approach ensuring validation of the occupant and seat model throughout (Pellettiere & Cheng, 2007 and Pellettiere, McHenry, Hu & Yang, 2008). One of the important parameters for the M&S of the seat cushions is the mechanical behavior of the materials used in the construction of the cushions (Pint et al., 2000). These materials could have some rate dependency, thus necessitating the use of non-linear methods and the development of visco-elastic material models (Cheng et al., 2003 and Cheng & Pellettiere, 2004b). Once the models for the foam materials had been developed, it was then necessary to continue this modeling effort to characterize the properties of human flesh (Darvish, Cheng, Smith & Pelletiere, 2008). This is extremely important for the comfort analysis as these properties will directly affect the interface pressures that would be generated (Cheng, Smith, Pelletiere & Fleming, 2007). The seat interface pressures would then be one of the parameters used in the validation process to determine the correlation between the model and the test data collected during the seat comfort studies. The result of this was a detailed finite element buttock and seat cushion finite element model to simulate pressure distributions which could then be used to predict comfort of different cushions.

2.4 Cockpit Accommodation

Sitting heights of 6 female and 7 male comfort test subjects were recorded using traditional anthropomety and an ACES II ejection seat. The males ranged in height from 66 to 73 inches and weight from 122 to 198 pounds. The females ranged in standing height from 62 to 68 inches and weight from 120 to 156 pounds. These test subjects were a subset of the subjects used in the Phase II comfort testing. The baseline ACES II cushion, the Goodrich air bladder cushion prototype, and the Oregon Aero contoured foam cushion prototype were tested and compared for differences in sitting height in the vertical direction with the head on or off the headrest as well as an angled sitting height with the head on the headrest. It should be noted that these measures were just to gather some preliminary data along with the comfort testing as no repeated measures were collected. It is recommended that a more complete study be conducted at a later date to fully assess any changes to the sitting height.

2.5 Vertical Impact

A series of +Z axis impact tests were conducted on the Vertical Deceleration Tower (VDT) (Figure 12) at Wright-Patterson Air Force Base, OH. Three manikins, a small female (LOIS) weighing 114 lbs., mid-sized male (50^{th} percentile Hybrid III Aerospace) weighing 180 lbs., and a large male (LARD) weighing 247 lbs. were used in this test program to simulate human response. Data collection consisted of manikin lumbar and cervical spine loads/forces and moments, head, chest and pelvis accelerations, shoulder straps and lap belt loads, seat pan and cushion accelerations, seat pan loads, carriage acceleration, carriage velocity, and high speed video. The data collected was used to support an objective analysis of the cushions' responses to impact. The impact test data has been uploaded and archived to the 711 HPW/RHPA Collaborative Biomechanics Data Network (CBDN) at https://www.biodyn.wpafb.af.mil.

Figure 12. Vertical Deceleration Tower (VDT)

2.6 Environmental

A full range of environmental tests were completed on the baseline ACES II cushion, Goodrich AIP air bladder cushion and Oregon Aero contoured foam cushion. Testing was accomplished by Dayton T. Brown, Bohemia, NY. The tests completed include:

- High Temperature: Method 501.4, Procedures I and II

- **Low Temperature:** Method 502.4, Procedures I and II
- **Humidity:** Method 507.4, 5 48-Hour Cycles, +140°F, 95% RH
- **Fungus:** Method 508.5, 28 Days
- **Salt Fog:** Method 509.4, 96 Hours, Alternating 24 Hours Wet/24 Dry
- **Dust:** Method 510.4, Procedure I, 12 Hours
- **Sand:** Method 510.4, Procedure II, 90 Minutes/Side
- **Explosive Decompression:** Method 500.4, Procedure IV, 8,000 Ft. to 40,000 Ft, Measure Deflection
- **Altitude Cycling Low Pressure:** 1,000 - 12,000 Ft, 1000 Cycles Ambient Temp, Run Cycle = 11Min., No Dwell Time
- **Flammability:** FAA FAR 25, Appendix F, Part 1 (b)(4)
- **Low Smoke Density:** Boeing Specification Support Standard BSS 7238
- **Low Toxicity:** Boeing Specification Support Standard BSS 7239
- **Electrical Surface Resistivity:** AATCC-76-2000
- **EMI Testing:** IAW MIL-STD-461E
    - **Radiated Emissions:** RE102 (10 kHz to 18 GHz)
    - **Radiated Susceptibility:** RS103 (2 MHz to 18 GHz at 60 V/m)

2.7 Vibration

A study was conducted to compare the biodynamic, subjective comfort, and occupant performance effects of the Goodrich air bladder seat pan cushion (Cushion B) and the Oregon Aero contoured prototype seat pan cushion (Cushion E) versus the standard seat pan cushion (similar to Cushion A) used in high performance military jets during exposure to low levels of vibration (Smith & Jurcsisn, 2010). Level flight vertical axis (Z) vibration acceleration collected on the F-15 was recreated in the 711 HPW/RHPA human-rated single-axis vibration facility. Subjects performed the NASA Multi-Attribute Task Battery (MATB) during 30-minute exposures to the vibration while seated on either a prototype cushion or the standard cushion. MATB is a PC-based multi-component performance test battery created by NASA. Figure 13 includes a subject performing the task. Figure 14 shows a more detailed view of the task display.

There were four tasks which the subjects conducted simultaneously. The tasks included a visual monitoring task with dials and lights (System Monitoring), a visual tracking task using a joystick (Tracking), a resource management task (Resource Management and Pump Status) and an auditory monitoring task (Communications). For this study, the Scheduling task was not performed. The joystick and keyboard-controlled tasks were generated onto a flat-panel display located in front of the subject (similar to one's desktop computer). The software package included the analysis of several variables depending on the particular task. In this study, the following task variables were included in the evaluation: Communications Response Time, Communications Response Error, Dials Response Time, Dials Response Error, Lights Response Time, Lights Response Error, System Monitoring Error, Tanks Deviation, and Tracking Error.

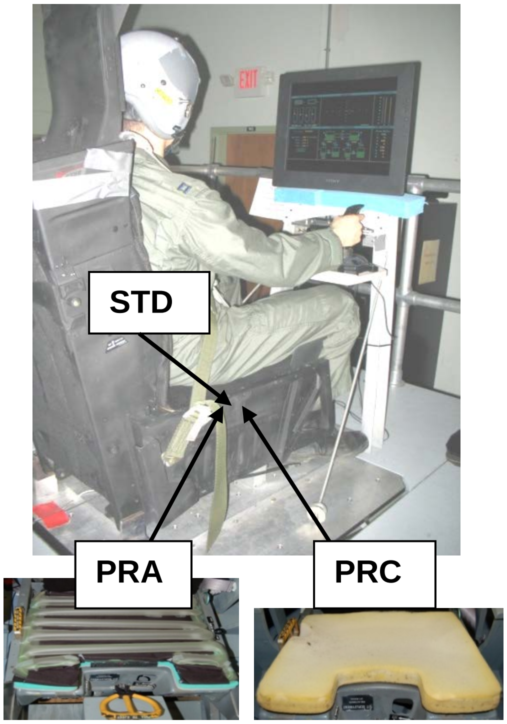


Figure 14. Subject Seated in Single-

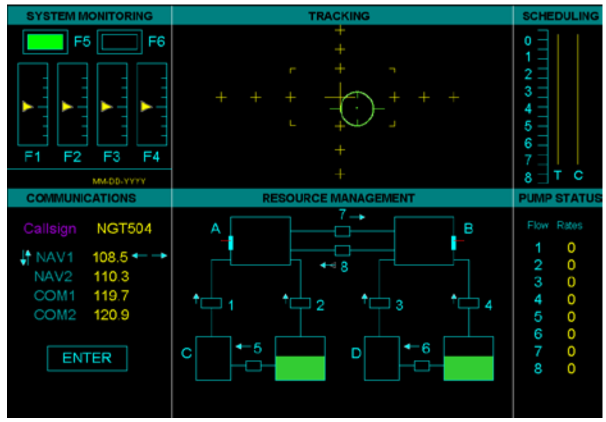


Figure 14. MATB Multi-Attribute Task

Following the exposure with each cushion, the subjects responded to the seat comfort survey developed by the TNO Defence, Security and Safety as described in Section 2.1.4.2. In addition the subjects were also exposed to a flat acceleration spectrum for evaluating the transmissibility characteristics of the tested seat cushion at the occupant/seat interface. Following a short rest period of approximately 5 minutes, during which time the cushion was replaced with either the prototype or standard, the subjects were again exposed to the low frequency vibration for 30 minutes and the process was repeated. Three sets of repetitions were performed for each prototype on separate days, and included switching the order of the cushion testing.

2.8 Sled Testing

The air bladder cushion was used during a Goodrich ACES V developmental ejection sled test. The sled test (HMTF 1045) was a 250KEAS test with a Large Anthropomorphic Device (LARD) manikin to represent a 95%ile occupant in height and weight. The cushion replaced the standard ACES cushion. Manikin lumbar loads were collected during ejection and compared to lumbar load injury criteria.

2.9 Flight Testing

Flight testing was performed to validate the utility and additional benefit of the cushions in a flight environment. The purpose of testing was two-fold: first, to evaluate the air bladder seat cushion for aircrew acceptability and, second, to evaluate the seat cushion for aircrew comfort.

Developmental flight testing of the air bladder seat cushion was performed at the AF Flight Test Center (AFFTC) located at Edwards AFB, CA in F-16C aircraft. The responsible test organization was the 412th Test wing. The 445th Flight Test Squadron conducted the testing.

One dedicated sortie and eighteen follow-on flight test missions were conducted, totaling nearly 23 test hours. Ten different test pilots evaluated the cushions.

3.0 RESULTS AND DISCUSSION

3.1 Comfort Testing

The XSENSOR pressure measurement system permits a wide variety of options for pressure mapping. Primary measurements were contact area, peak pressure, and area of peak pressure. After a six minute settling period these values will be recorded for five minutes for Cushions A, B, C and for eight minutes for Cushion D. Previous research has shown the best cushions usually have the lowest peak pressures, equal pressure distribution per half area, and largest overall contact areas (Stubbs et al., 2005). This is true for foam type cushions; however air bladder cushions are different. The higher peak pressures results in a more comfortable cushion. The high peak pressure indicates that the air bladder is making good contact with the surface of the body, thus lifting the occupant in order to stimulate blood flow to the lower extremities. The air bladder cushion cycles through an inflation and deflation cycle, so over time, the peak pressure will change and not be a constant. This makes a direct comparison of just the pressure distribution difficult.

Only the data from the 8-hour Phase I testing was analyzed for peak and average pressure and contact area. The Phase II data was subjectively evaluated and will be documented in a future report. Cushion C had the highest average seat pressure, around 0.67 Psi, whereas Cushion B had the lowest average seat pressure around 0.6 Psi (Figure 15). For male subjects, Cushion C had the highest average seat pressure of 0.70 Psi and Cushion B had the lowest average seat pressure of 0.63 Psi. For female subjects, Cushion C had the highest average seat pressure of 0.64 Psi, but Cushion A had the lowest average seat pressure of 0.59 Psi. Cushion A had the lowest contact area of 212.67 Sq in, while cushion C had the highest contact area of 219.82 Sq in (Figure 16). For male subjects, Cushion A had the lowest contact area of 211.84 Sq in and Cushion D had the highest contact area of just over 220 Sq in. For female subjects, Cushion A had the lowest contact area of 213 .85 Sq in Cushion B had the highest contact area 221.12 Sq in.

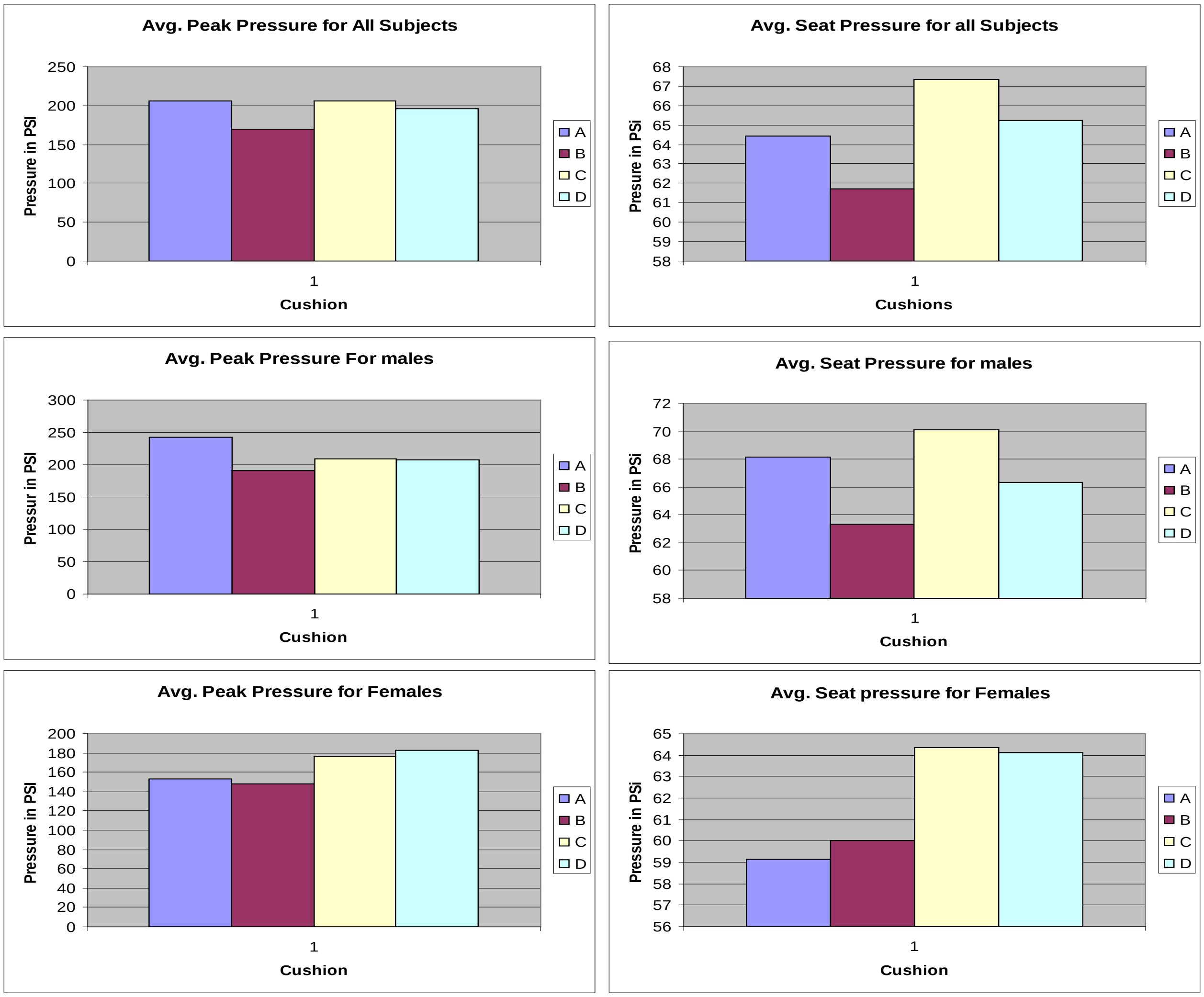


Figure 15. XSensor Pressure Results (Phase I 8-hour Study) (Units are PSI/100)

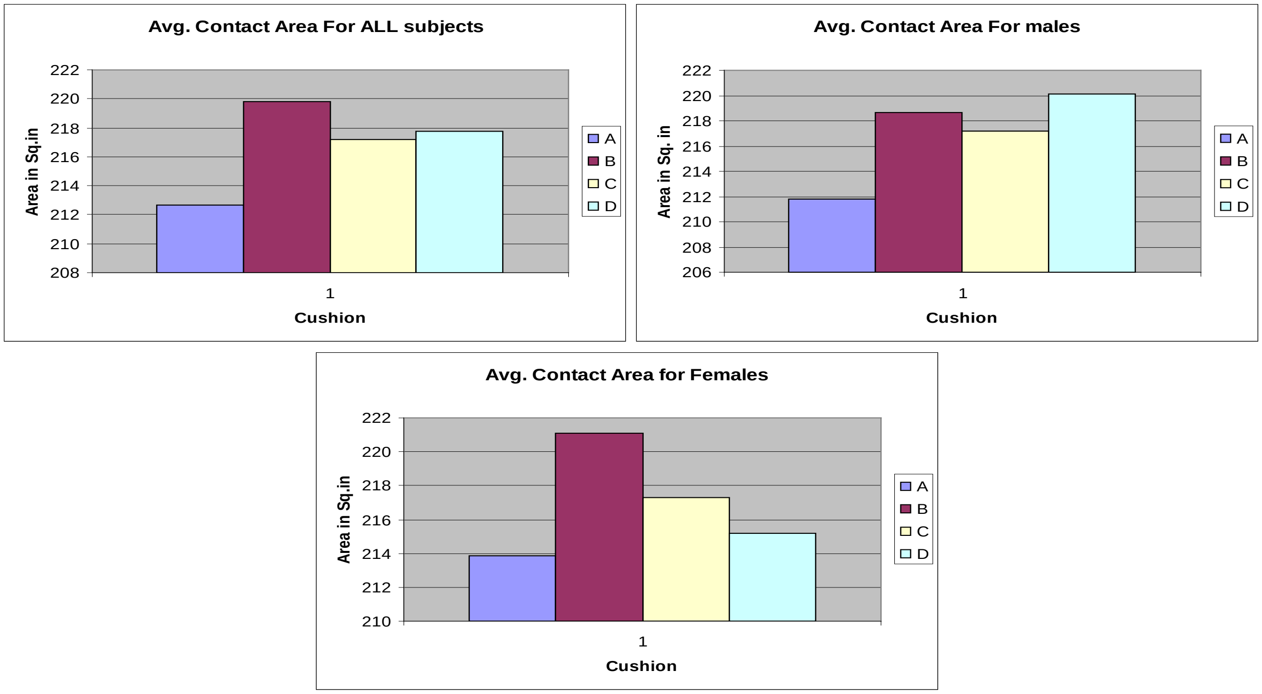


Figure 16. XSensor Contact Results (Phase I 8-hour Study)

The Oximeter data were analyzed for changes in oxygen saturation over the eight hours. Twenty-four subjects (12 female, 12 male) had completed data from participation in this study. O_2 saturation was measured on the bulk of the calf muscle approximately every 5 seconds. Baseline saturation was defined as the O_2 measured over the first 5 minutes. Average saturation values during baseline, after baseline until 2 hours, from 2 hours through 4 hours, from 4 hours through 6 hours, and from 6 hours through 8 hours were determined for each subject. These averages were then averaged across subjects (Table 1 and Figure 17).

Table 1. Mean percent change in O_2 saturation from baseline (first 5 minutes). *p-values are from two-tailed t-tests without pooled error (i.e., each test only used percent changes from that group, time change, and cushion) for Ho: mean % change = 0.*

Time Change	Cushion	Overall		Female		Male	
		Mean	p	Mean	p	Mean	p
0-2 Hr	A	-3.28	0.0024	-1.78	0.1893	-4.78	0.0065
	B	-0.24	0.6887	1.29	0.6258	-1.78	0.0730
	C	-1.97	0.0898	-2.58	0.1616	-1.36	0.3348
	D	-3.41	0.0081	-2.06	0.2845	-4.75	0.0128
0-4 Hr	A	-4.50	0.0020	-1.61	0.4368	-7.38	0.0008
	B	-2.30	0.0555	0.84	0.6580	-5.44	0.0138
	C	-3.45	0.0412	-2.23	0.3350	-4.67	0.0745
	D	-4.47	0.0131	-0.44	0.9942	-8.50	0.0014
0-6 Hr	A	-4.86	0.0008	-1.30	0.5223	-8.41	0.0002
	B	-2.74	0.0748	0.22	0.8913	-5.69	0.0185
	C	-2.74	0.0933	0.92	0.7151	-6.39	0.0136
	D	-4.67	0.0104	-0.69	0.9228	-8.65	0.0014
0-8 Hr	A	-4.39	0.0030	-0.46	0.8182	-8.31	0.0007

	B	-2.47	0.0565	0.59	0.8472	-5.54	0.0085
	C	-1.41	0.3872	1.70	0.5737	-4.52	0.0512
	D	-4.75	0.0110	-1.14	0.8694	-8.36	0.0010

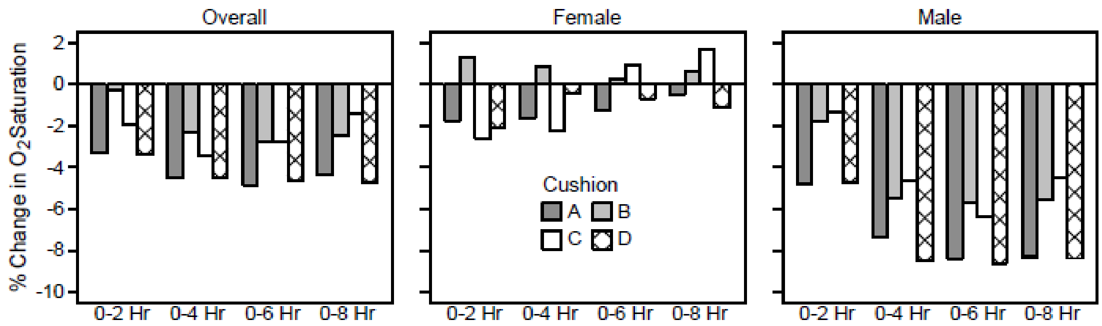


Figure 17. Mean percent change in O_2 saturation from baseline (first 5 minutes)

Using two-tailed t-tests, none of the mean percent changes were significant ($p > 0.1616$) for the females, however, all of the percent changes for the males were significant ($p \leq 0.05$) except cushions B and C at 0-2 Hr, cushion C at 0-4 Hr, and cushion C at 0-8 Hr.

Paired comparisons of cushion were made for each combination of group (overall, female, male) and time change using two-tailed paired t-tests for females and males and two-tailed t-tests adjusting for gender for overall. There were no significant paired comparisons for females or males ($p > 0.0660$). The only significant paired tests ($p \leq 0.05$) for overall were A vs. B at 0-2 Hr ($p = 0.0098$), B vs. D at 0-2 Hr ($p = 0.0232$), and C vs. D at 0-8 Hr ($p = 0.0347$).

A mixed model analysis of variance was performed using gender as a between factor with time change and cushion within factors. Subject was considered random and effects involving subject were used as the error term for all tests (Table 2). Significant effects were gender (mean % change: female = -0.6, male = -5.9) and gender*time change. Repeated measures analyses of variance for each gender separately showed little change over the 8 hours for the females ($p = 0.3747$) while males had significant differences over the 8 hours ($p = 0.0001$). In particular, for the males there was a significant difference between 0-2 hours and each of the other three time changes ($p \leq 0.0004$) with no significant paired differences among 0-4 hours, 0-6 hours, and 0-8 hours ($p > 0.4208$). Male mean percent change for each time change were: 0-2 hours = -3.2%, 0-4 hours = -6.5%, 0-6 hours = -7.3%, 0-8 hours = -6.7%.

Table 2. Results from mixed model analysis of variance

G-G is Greenhouse-Geisser correction.

Source	DF	SS	DFe	SSe	F	p	G-G Ep	G-G p
Gender (G)	1	2770.20	22	6988.66	8.72	0.0074		
Time (T)	3	139.37	66	1342.52	2.28	0.0870	0.52	0.1279
Cushion (C)	3	443.42	66	5755.51	1.69	0.1766	0.77	0.1898
G*T	3	421.25	66	1342.52	6.90	0.0004	0.52	0.0056
G*C	3	94.22	66	5755.51	0.36	0.7820	0.77	0.7290
T*C	9	63.92	198	1525.37	0.92	0.5071	0.50	0.4624

G*T*C	9	87.31	198	1525.37	1.26	0.2613	0.50	0.2897

Females showed little change in O_2 saturation over time and among the cushions. Males showed a significant drop in O_2 saturation from baseline to 2 hours and from 2 hours to 4 hours. After 4 hours, O_2 saturation stabilized. For the males, statistical tests were not able to show meaningful differences in the cushions, however, means and a few paired tests indicated cushions B and C had similar results while cushions A and D had similar results with cushions A and D having greater decreases in O_2 saturation than cushions B and C.

The SynWin software package has built-in capabilities for score evaluation and also allows for export to Microsoft Excel for greater user control of evaluation. Pertinent data such as reaction time and false selections are scored. For this evaluation, only the total composite score as provided by SynWin was used. It can be observed that the overall scores improved over the 8-hour period (Figure 18) especially for cushion B, subjects exhibited a steady increase in performance until the end. Interestingly, the male performance while seated on cushion D steadily increased over the 8-hour session as compared to the female subjects. A decline in performance is observed for cushion A, but this decline cannot be conclusively attributed to the comfort level of the cushions. This issue requires further analysis. The scores could have improved from learning effects on the required task.

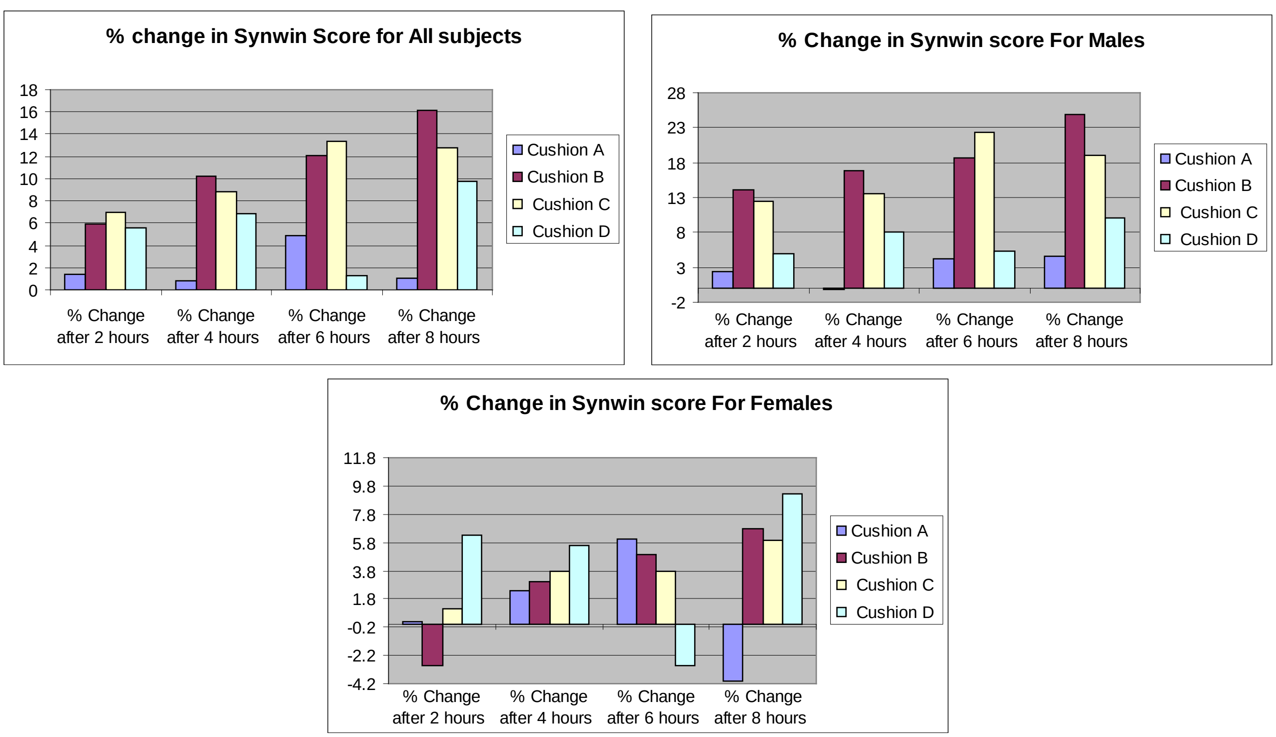


Figure 18. SynWin Task Results (Phase I 8-hour Study)

The comfort survey data were evaluated to identify trends for each cushion. An issue with the data storage from Phase I was encountered which prevented a meaningful analysis. If this can be resolved in the future, then the results from Phase I will be presented at that time. For now, only the data from Phase II was analyzed.

Figure 19 shows the Local Perceived Discomfort (LPD) plus one standard deviation for the back, buttocks, and legs for all test subjects for each of the five cushions tested over the 4-hour time period (Phase II). These combined body areas showed the highest ratings. The perception of discomfort is less when the number is closer to 0, thus resulting in a more comfortable cushion. The figure shows that, although the mean values were quite low, the variations in the LPD were quite large among the subjects. There was a tendency for increasing discomfort with time (statistical analysis not done). For the 4th hour LPD, the Repeated Measures Analysis of Variance (RM ANOVA) and Bonferroni t-test showed that Cushion A produced a significantly higher discomfort value as compared to Cushion D ($P \leq 0.05$). No other significant effects were observed in the LPDs.

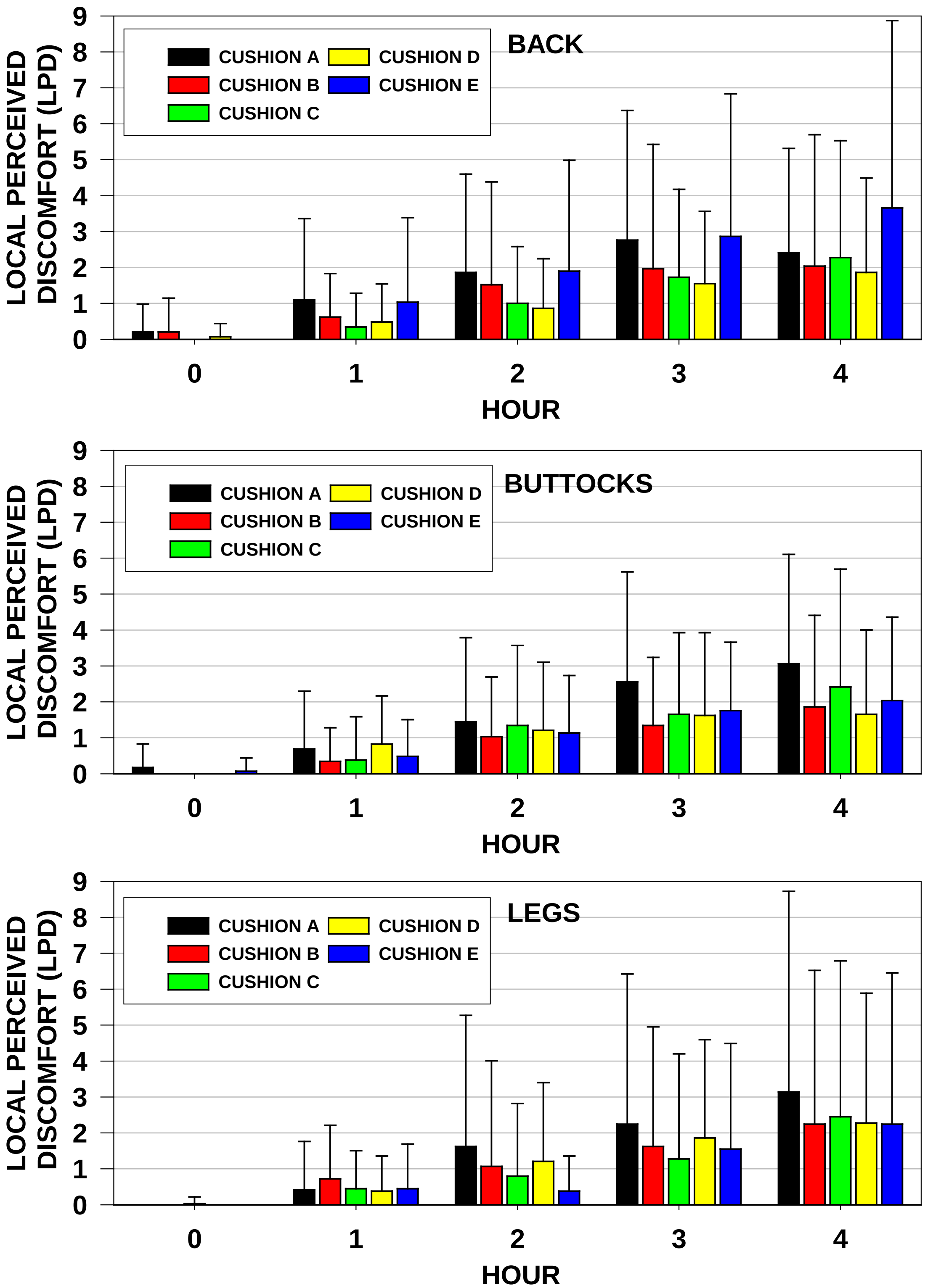


Figure 19. Local Perceived Discomfort (LPD) (Phase II 4-hour Study)

Figure 20 illustrates the mean seat ratings plus one standard deviation for the seat pan firmness, seat back firmness, lower back support and comfort, buttocks support and comfort, and thigh/leg

support and comfort. The absolute values of the firmness and support ratings were used for the analysis.

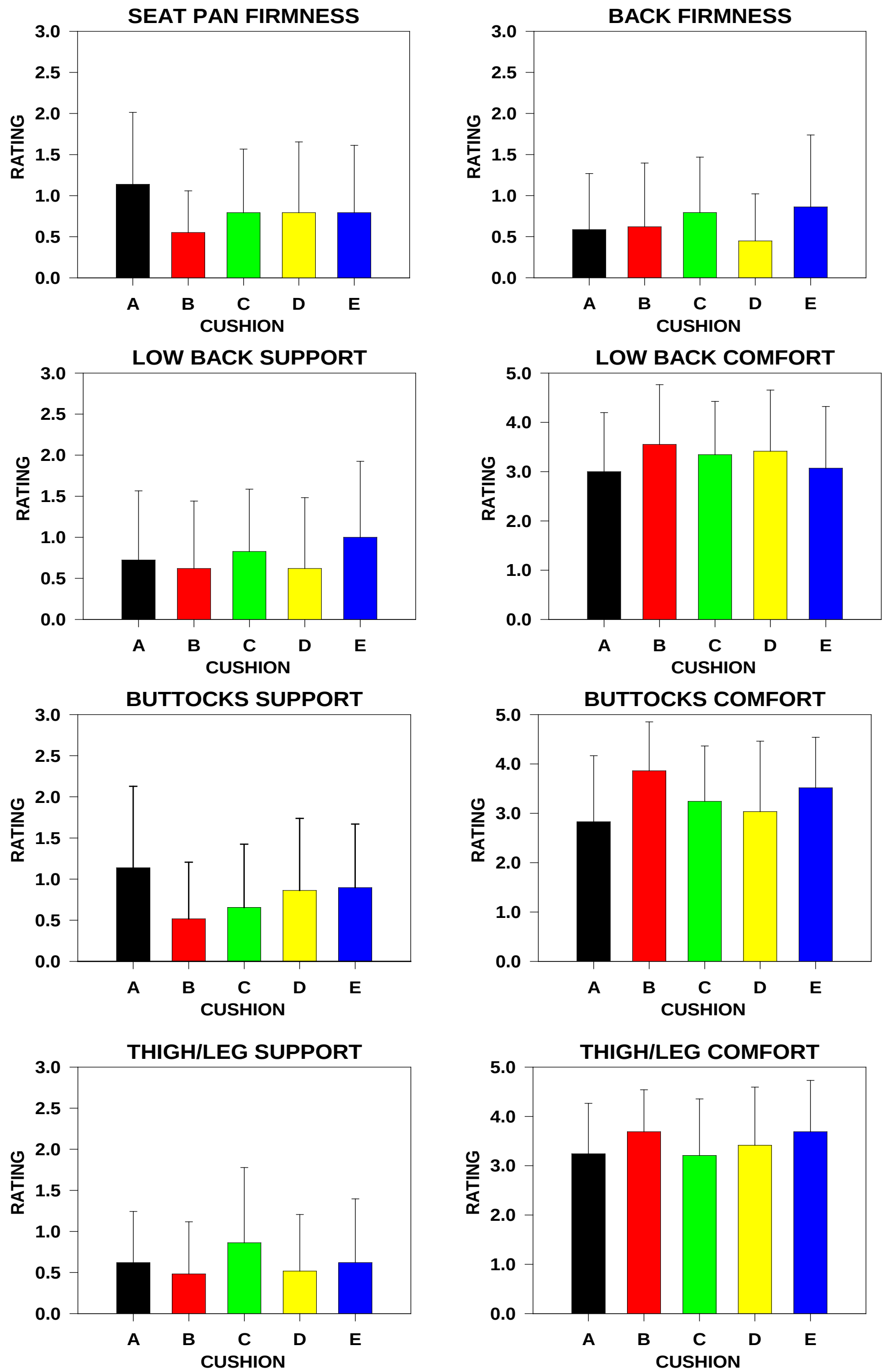


Figure 20. Seat Ratings (Phase II 4-hour Study)

The RM ANOVA and Bonferroni t-test showed that the seat pan firmness rating for Cushion B was significantly lower as compared to Cushion A, indicating that Cushion B, which showed the lowest mean absolute rating, had more adequate firmness ($P \leq 0.05$). The statistical analysis

showed that the buttocks support rating for Cushion B was significantly lower as compared to Cushion A, indicating that Cushion B, which showed the lowest mean absolute support, had more adequate buttocks support ($P \leq 0.05$). The statistical analysis also showed that the buttocks comfort rating for Cushion B was significantly higher as compared to Cushions A and D, indicating that Cushion B, which showed the highest mean comfort rating, provided greater buttocks seated comfort ($P \leq 0.05$). No other significant effects were observed in the seat ratings.

3.2 Simulator Testing

All 11 pilots provided positive feedback on the cushions and no negative effects on the pilot's performance were noted. It was determined that the cushions were not statistically different from one another with respect to the effect on the pilot's performance during a series of approaches and landings over the course of one hour in the simulator.

All 4 pilots who used the air bladder cushions in the B-2 simulators for 24 hours provided positive feedback on the performance of the air bladder cushions. Specific feedback is not contained in this report as assurances were made to the community that their comments would remain protected and their purpose was to gather evaluative data on which to base design decisions.

3.3 Modeling

The comfort performance of a cushion can be improved by optimizing its material properties and configuration. Computational modeling and simulation of various designs can be an effective and efficient way to optimize the comfort performance of a cushion.

Whereas an FE human buttock model was developed in this project, more work on the model is needed in order to use it for practical applications, which includes the model validation, modification, and refinement. To scale the base model, especially the buttock outer shape to represent a particular test subject according to his or her 3D laser scan data, is one of our interests and will be investigated in the future.

The results of the modeling were presented at the 2007 Digital Human Modeling Conference (Cheng et al., 2007). Additional information on the modeling efforts is located in Appendix B.

3.4 Cockpit Accommodation

Subject sitting height (Table 3) was measured during comfort testing of the cushions for some subjects. The sitting height difference between the standard ACES II cushion and the prototype cushions are recorded here. On average for the female subjects (weight not accounted for) the air bladder cushion raised the subject 1.7cm (0.67in) while the foam cushion raised the subject 2.4 in (0.95in). For the male subjects, the air bladder cushion raised the subject 1.3cm (0.51in) and the contoured foam cushion 2.9cm (1.14in). Numbers in parentheses are the standard deviation. Note these are quite high as there were only a few subjects and the weight of subject was not accounted for. It is recommended that a more complete study be conducted on the changes to the sitting height for the cushions to be conducted which includes more subjects, repeated measures and control of the inflation cycle of the air bladder.

Table 3. Sitting Height Changes vs. Standard Cushion (cm)

	Air Bladder Cushion	Oregon Aero Foam Cushion	Oregon Aero Foam Cushion after 15min*
Female	1.7 (0.4)	2.4 (0.7)	
Male	1.3 (1.15)	2.9 (0.47)	1.1 (0.33)

*Only Large Males used

3.5 Vertical Impact

3.5.1 Evaluation Criteria

The resultant lumbar load limits are as follows:
5th Percentile (LOIS): Less than 1,000 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

50th Percentile: Less than 1,500 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

95th Percentile: Less than 2,200 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

Rationale for the maximum lumbar load limits
The dynamic test lumbar spinal load of 2206 pounds for the large manikin was calculated based on the Federal Aviation Administration's maximum load of 1500 pounds for a 170 pound occupant. The number was scaled up to be commensurate with the seat cushion assembly specification requirement for a 250 pound occupant using the following formula:

$$\frac{1500 \text{ lb X } 250 \text{ lb}}{170 \text{ lb}} = 2206 \text{ lb}$$

Likewise, the number was scaled down to be commensurate with the seat cushion assembly specification requirement for the small occupant.

3.5.2 Results

The resultant lumbar loads for both the November 2007 (Table 4) and January 2009 (Table 5) passed the acceptance criterion.

Table 4. Manikin Resultant Lumbar Loads for November 2007

Cushion	Manikin	Level (G)	Resultant Load (lbs)	Cushion Type	Notes
A	95th Aero	12	1817	Goodrich ACES II	Std ACES II cushion

A	95th Aero	12	1777	Goodrich ACES II	Std ACES II cushion
Ba	95th Aero	12	1825	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Ba	95th Aero	12	1853	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	95th Aero	12	1818	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	95th Aero	12	1780	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
C	95th Aero	12	1782	Oregon Aero EPCT Foam	Similar to current B2 cushion
C	95th Aero	12	1725	Oregon Aero EPCT Foam	Similar to current B2 cushion
A	50th Aero	12	1334	Goodrich ACES II	Std ACES II cushion
A	50th Aero	12	1292	Goodrich ACES II	Std ACES II cushion
Ba	50th Aero	12	1347	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Ba	50th Aero	12	1294	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	50th Aero	12	1263	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	50th Aero	12	1409	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	50th Aero	12	1394	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
C	50th Aero	12	1415	Oregon Aero EPCT Foam	Similar to current B2 cushion
C	50th Aero	12	1389	Oregon Aero EPCT Foam	Similar to current B2 cushion
A	5th Lois	12	644	Goodrich ACES II	Std ACES II cushion
A	5th Lois	12	634	Goodrich ACES II	Std ACES II cushion
Ba	5th Lois	12	627	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Ba	5th Lois	12	709	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Ba	5th Lois	12	682	Goodrich C45 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	5th Lois	12	691	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	5th Lois	12	634	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi
Bb	5th Lois	12	668	Goodrich C47 Air Bladder w/blow off valve	Normal Operation 1 bladder filled ~3 psi

C	5th Lois	12	679	Oregon Aero EPCT Foam	Similar to current B2 cushion
C	5th Lois	12	672	Oregon Aero EPCT Foam	Similar to current B2 cushion

Table 5. Resultant Lumbar Loads for January 2009

Cushion	Manikin	Level (G)	Resultant Load (lbs)	Cushion Type	Notes
A	95th Aero	12	1440	Goodrich F-16 ACES II Foam	Std ACES II cushion
A	95th Aero	12	1488	Goodrich F-16 ACES II Foam	Std ACES II cushion
A	95th Aero	12	1418	Goodrich F-16 ACES II Foam	Std ACES II cushion
B	95th Aero	12	1463	Goodrich C47 Air Bladder	Normal Operation 1 bladder filled ~3 psi
B	95th Aero	12	1369	Goodrich C47 Air Bladder	Normal Operation 1 bladder filled ~3 psi
B	95th Aero	12	1465	Goodrich C47 Air Bladder	Normal Operation 0.5 PSI in both bladders
B	95th Aero	12	1328	Goodrich C47 Air Bladder	Normal Operation 0.5 PSI in both bladders
C	95th Aero	12	1431	Oregon Aero EPCT Foam	Similar to current B2 cushion
C	95th Aero	12	1394	Oregon Aero EPCT Foam	Similar to current B2 cushion
A	50th Aero	12	1200	Goodrich F-16 ACES II Foam	Std ACES II cushion
A	50th Aero	12	1176	Goodrich F-16 ACES II Foam	Std ACES II cushion
B	50th Aero	12	1099	Goodrich C47 Air Bladder	Normal Operation 1 bladder filled ~3 psi
B	50th Aero	12	1135	Goodrich C47 Air Bladder	Normal Operation 1 bladder filled ~3 psi
B	50th Aero	12	1073	Goodrich C47 Air Bladder	Normal Operation 0.5 PSI in both bladders
B	50th Aero	12	1141	Goodrich C47 Air Bladder	Normal Operation 0.5 PSI in both bladders
C	50th Aero	12	1157	Oregon Aero EPCT Foam	Similar to current B2 cushion
C	50th	12	1127	Oregon Aero EPCT Foam	Similar to current B2

	Aero				cushion
A	Lois	12	803	Goodrich F-16 ACES II Foam	Std ACES II cushion
A	Lois	12	839	Goodrich F-16 ACES II Foam	Std ACES II cushion
B	Lois	12	993	Goodrich C47 Air Bladder	Normal Operation 1 bladder filled ~3 psi
B	Lois	12	885	Goodrich C47 Air Bladder	Normal Operation 1 bladder filled ~3 psi
B	Lois	12	958	Goodrich C47 Air Bladder	Normal Operation 0.5 PSI in both bladders
B	Lois	12	947	Goodrich C47 Air Bladder	Normal Operation 0.5 PSI in both bladders
C	Lois	12	897	Oregon Aero EPCT Foam	Similar to current B2 cushion
C	Lois	12	879	Oregon Aero EPCT Foam	Similar to current B2 cushion

A total of 52 tests were conducted and analyzed at the 12 G level. The tests were conducted at 12 G on the Air Force Research Laboratory's Vertical Deceleration Tower at Wright-Patterson Air Force Base, OH, using a small (LOIS), mid-sized (modified 50th percentile aerospace Hybrid III) and large manikin (LARD).

In order to quantify the phase I production seat pan cushions' responses to the acceleration levels, and investigate the occupant risk implications associated with these cushions, one should consider the resultant lumbar loads (lbf).

Generally, the phase I production supplied cushions resulted in similar resultant lumbar loads for the all manikins tested as compared to those of the baseline factory-installed F-16 ACES II cushions.

None of the lumbar loads exceeded the recommended maximum lumbar load limits. None of the seat pan DRI's exceeded the limit of 18.

When the November 2007 and January 2009 lumbar loads are compared, the measured lumbar loads between the two test series are different for each occupant size. This is due to differences in the ballasting of the manikin. Of most importance is the consistency of lumbar loads between cushions that show no additional probability of injury with the prototype cushions.

For the 95%ile Male manikin, resultant lumbar loads were similar between the cushions and well below the lumbar load criteria of 2200lbs (Figures 21 and 22).

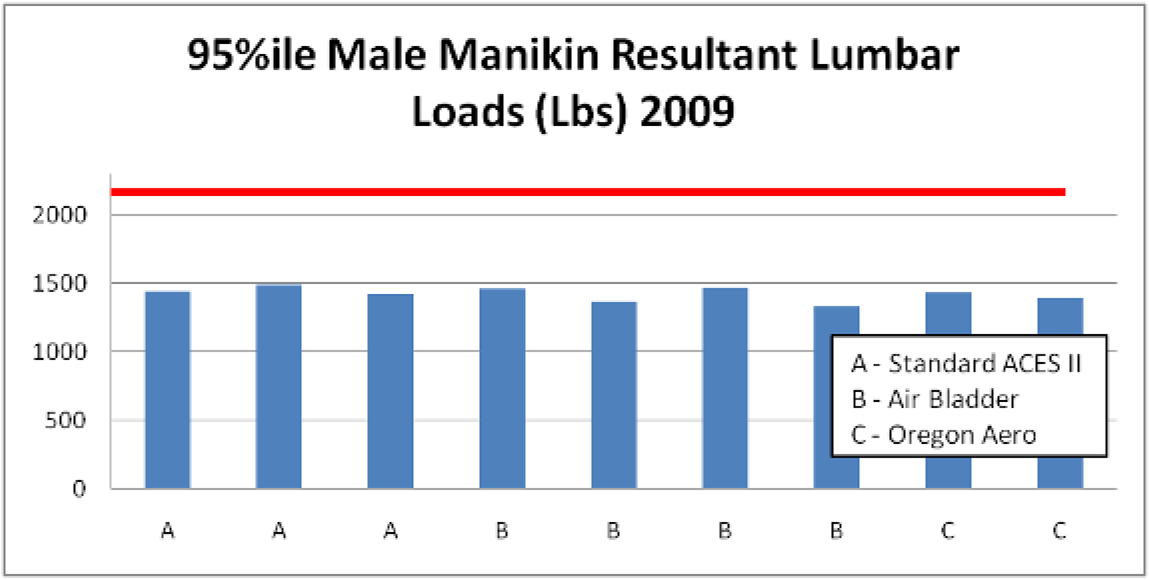


Figure 21. 95%ile Male Manikin Resultant Lumbar Loads (lbs) 2009

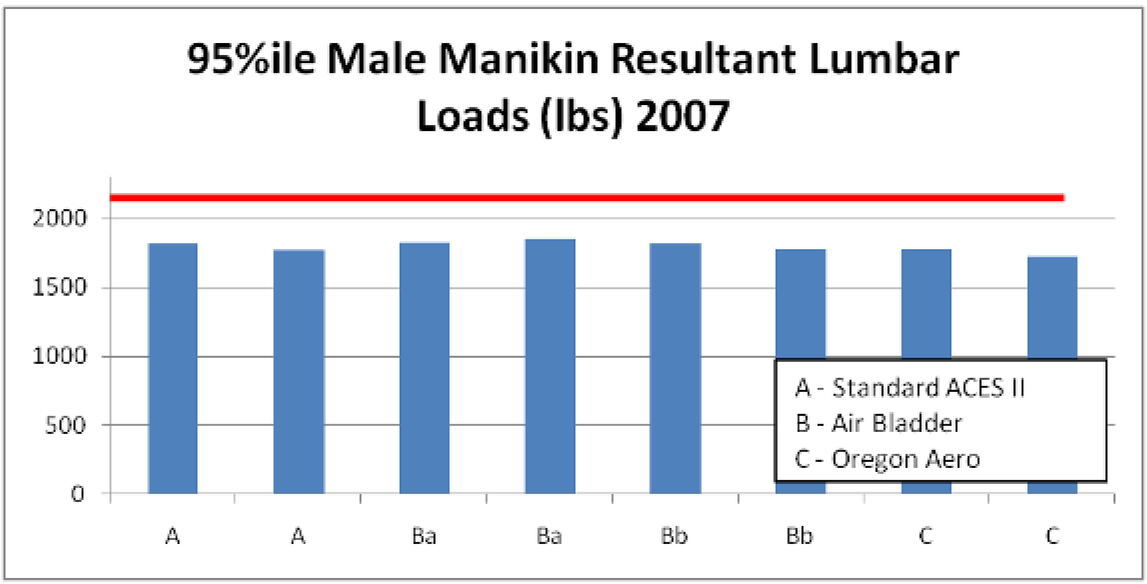


Figure 22. 95%ile Male Manikin Resultant Lumbar Loads (lbs) 2007

For the 50%ile male manikin, resultant lumbar loads were also similar between cushions and also well below the JSF lumbar load criteria of 1500lbs (Figures 23 and 24).

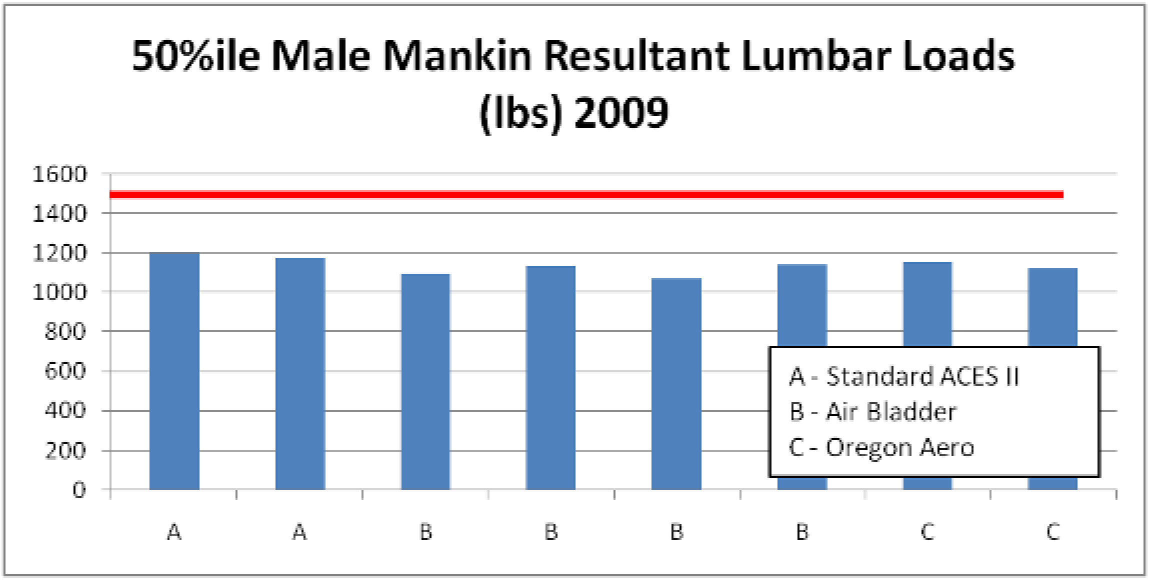


Figure 23. 50%ile Male Manikin Resultant Lumbar Loads (lbs) 2009

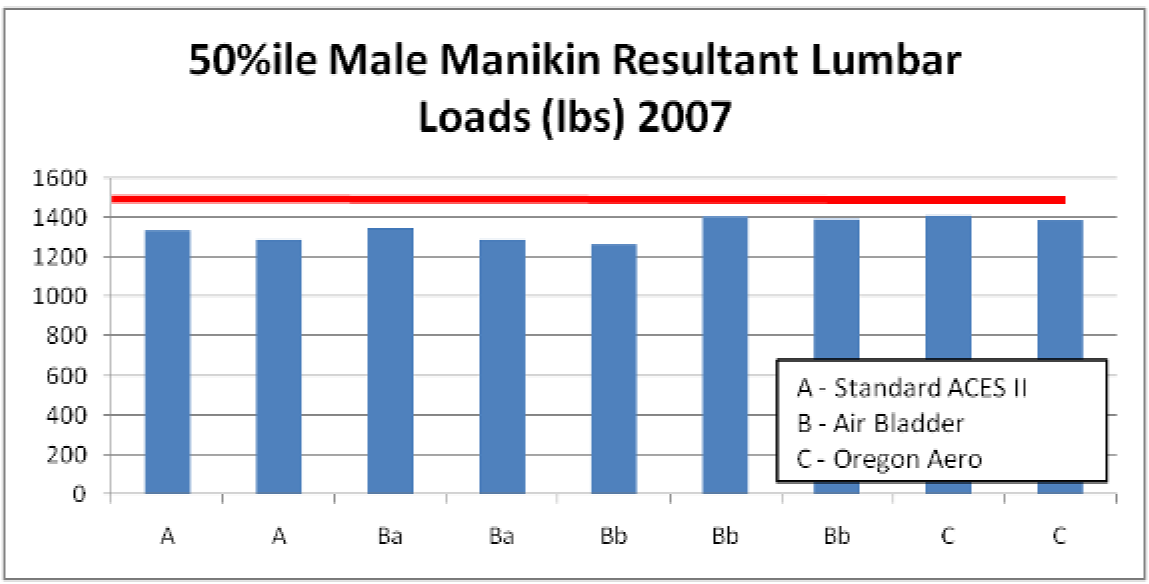


Figure 24. 50%ile Male Manikin Resultant Lumbar Loads (lbs) 2007

For the 5%ile female manikin, resultant lumbar loads were similar between cushions (Figures 25 and 26). Of note the lumbar loads for the air bladder cushion were close to the lumbar load criteria of 1000lbs. However, the measured loads from 2009 when compared to data collected in 2007 are consistently higher. This is caused due to differences in ballasting the mankin. Of most importance is the consistency of lumbar loads between cushions that show no additional probability of injury with the prototype cushions.

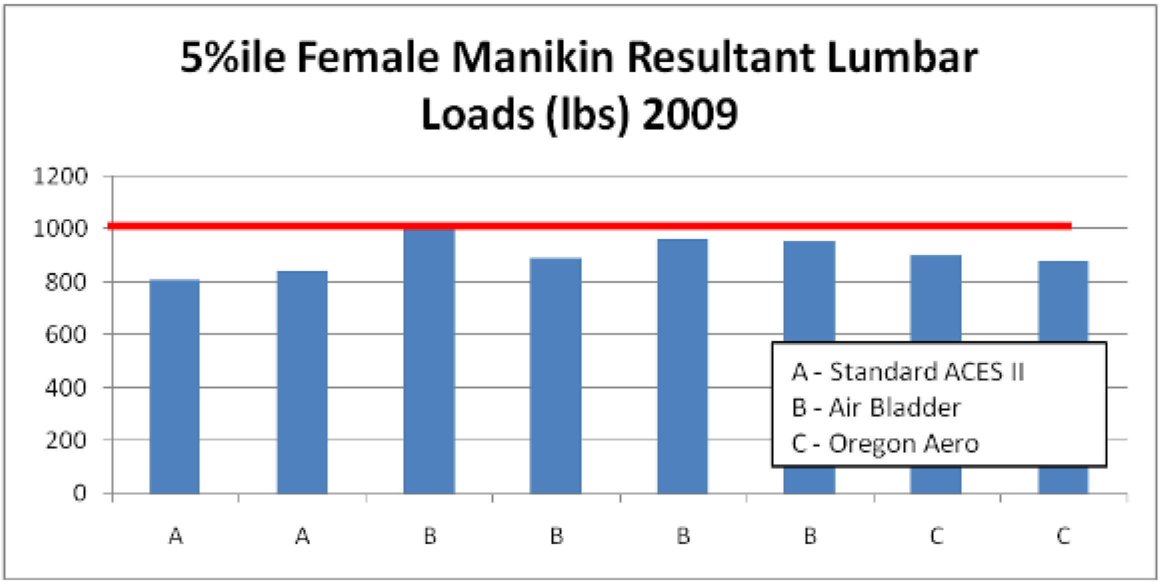


Figure 25. 5%ile Female Manikin Resultant Lumbar Loads (lbs) 2009

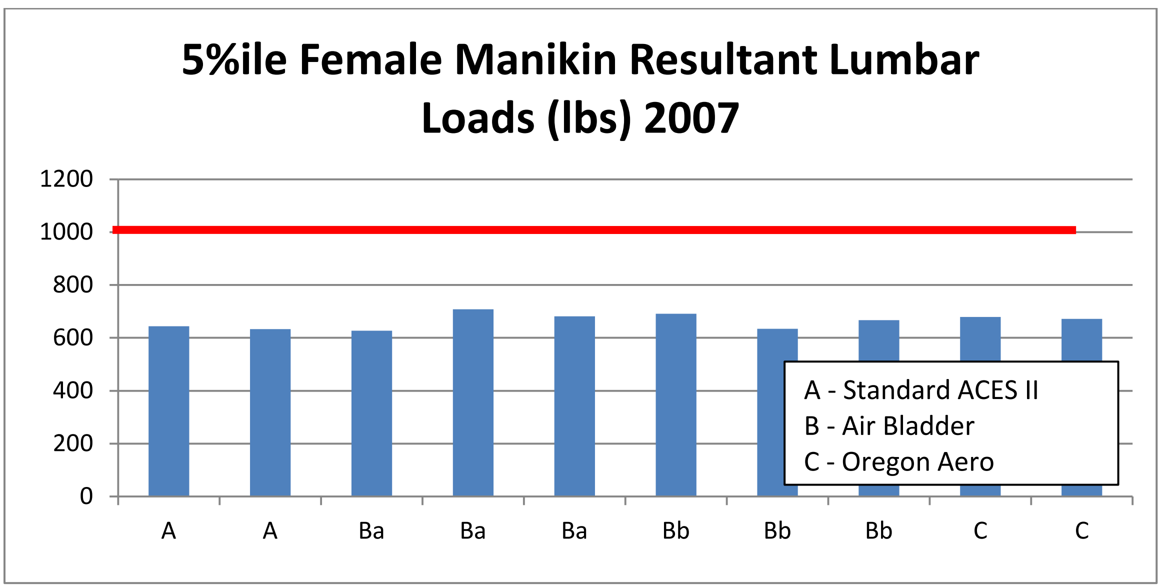


Figure 26. 5%ile Female Manikin Resultant Lumbar Loads (lbs) 2007

3.6 Environmental

A summary of the environmental results are given below. The full test report is attached as Appendix E. The full test report for the EMI testing is in Appendix F. The full test report for the flammability testing is located in Appendix G.

High temperature storage and operation – The air bladder cushion functioned after the storage test. The air bladder cushion malfunctioned during and after operation of the test. The cushion was reset several times in an attempt to get it working. This failure was most likely caused from

an electric static discharge (ESD) flaw in the version of the prototype cushion tested. This test will need to be repeated prior to a full safe-to-fly.

Humidity – The air bladder cushion functioned immediately after humidity test, though malfunctioned a few minutes later. This failure was most likely caused from a now-fixed flaw in the cushion. This test will need to be repeated prior to a full safe-to-fly.

Low temperature storage and operation – The air bladder cushion functioned after storage test. The air bladder cushion malfunctioned during the operation test. This failure was most likely due to the ESD flaw in the cushion. This test will need to be repeated prior to a full safe-to-fly. The air bladder cushion successfully functioned after the operational test when it was returned to a normal temperature.

Altitude – the air bladder cushion successfully functioned during the altitude testing. Post –test, the cushion required a reset. This is most likely due to a now-fixed flaw in the cushion. This test will need to be repeated prior to a full safe-to-fly.

Blowing dust – the air bladder cushion was not operational post-test. This is most likely due to a now-fixed flaw in the prototype cushion. This test will need to be repeated prior to a full safe-to-fly.

Salt fog – the air bladder cushion successfully functioned after the testing.

Blowing sand – the air bladder cushion was not operational after testing. This is most likely due to a now-fixed flaw in the prototype cushion. This test will need to be repeated prior to a full safe-to-fly.

Fungus – the Oregon Aero cushion as well as the baseline ACES II cushion had significant fungus growth. The air bladder cushion had a small area with fungal growth.

Explosive Decompression – the air bladder cushion required resetting of the prototype during the test. This is most likely due to a now-fixed flaw in the prototype cushion. This test will need to be repeated prior to a full safe-to-fly.

Toxicity – standard ACES II cushion, the air bladder, and the Oregon Aero cushion all passed the toxicity tests.

Smoke generation – the air bladder and Oregon Aero cushion passed the smoke generation test while the standard ACES II cushion did not pass.

Flammability – the air bladder cushion, Oregon Aero, and standard ACES II cushion covers were tested. The sheepskin cover used on all the cushions passed, though the Oregon Aero cloth cover did not pass.

Electromagnetic Interference (EMI) – the air bladder cushion passed the EMI testing. The standard cushion as well as the Oregon Aero cushion were not tested as they do not include any electronics within the cushion.

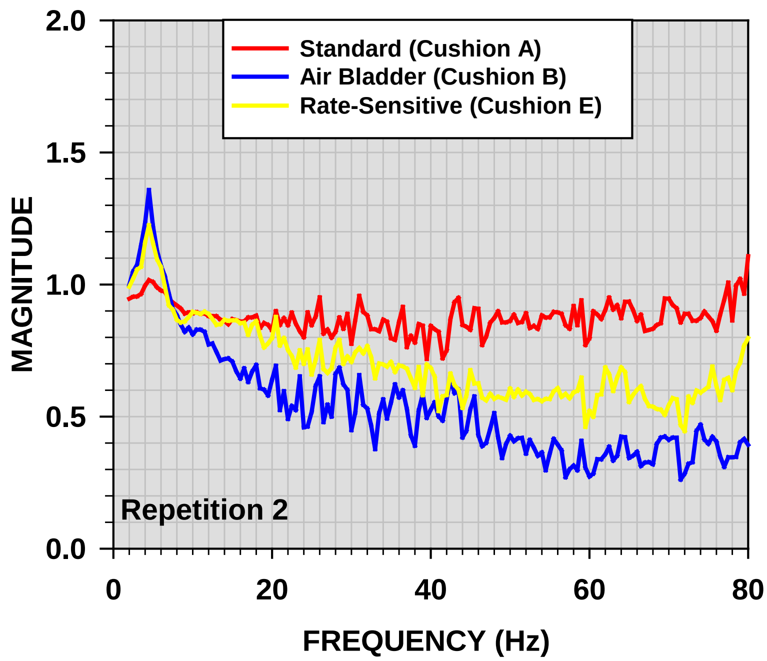
3.7 Vibration

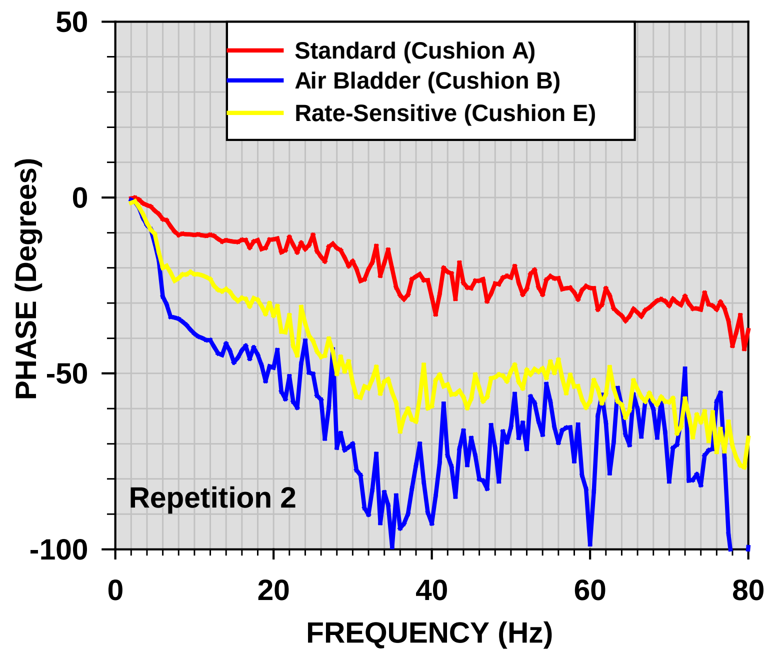
In general, none of the variables evaluated from the MATB tasks were significantly different when compared among the cushion configurations (Smith & Jurcsisn, 2010). This was expected due to the extensive training period undertaken by the military subjects and the relatively short exposure times (30 minutes). For the Local Perceived Discomfort (LPD) portion of the comfort survey, responses greater than zero were only provided for the back, buttocks and legs. It was difficult to determine if subjects were providing the zero ratings for the respective body parts, or whether it was the default rating. Due to the limited responses and questionable ratings, statistical analysis was not accomplished on the LPD data. The most notable difference occurring in the seat ratings portion of the comfort survey was associated with the Seat Pan Firmness. For two of the three repetitions, the seat pan firmness was rated as being more firm with the standard cushion (Cushion A) as compared to the Goodrich air bladder cushion (Cushion B). For one of the three repetitions, the standard cushion (Cushion A) was also rated more firm than the Oregon Aero contoured cushion (Cushion E). These results were significant. All cushions tended to be too firm and tended to provide too little buttocks support. The comfort rating for the buttocks was quite variable among the subjects. Thigh/leg support tended to be adequate with less variability among the subjects as compared to buttocks support. The thigh/leg comfort also tended to be rated higher for comfort as compared to buttocks, ranging between 3 and 5. The only significant effect among the cushions occurred for thigh/leg comfort. The Oregon Aero contoured cushion (Cushion E) was considered to have greater thigh/leg comfort as compared to the standard cushion.

The transmissibility data do strongly suggest differences among the cushions, particularly between the two prototypes tested and the standard cushion (Figures 27 and 28). Both prototypes showed a significantly higher transmissibility magnitude between about 4.5 and 5 Hz as compared to the standard cushion with means of approximately 1.30 – 1.4 for the air bladder cushion (Cushion B), 1.25 – 1.3 for the contoured cushion (Cushion E), and 1.0 for the standard cushion (Cushion A). In contrast, both prototypes showed greater dampening (transmissibility magnitude < 1) beyond about 6 Hz as compared to the standard cushion. The greatest dampening was observed with the air bladder cushion (Cushion B). Both prototypes also showed higher phase shifts beyond 6 Hz related to the dampening behavior. All cushions showed mean transmissibility magnitudes below 1 at around 8.5 – 9.0 Hz, where a resonance peak was observed in the F-15 acceleration spectra entering the seating system. This peak was associated with structural characteristics of the F-15. While the vibration at this resonance can be substantial in this aircraft during high angle of attach maneuvers, the levels appear to be quite low during level flight. For other jet aircraft, it is assumed that any vibration generated by the vehicle occurs primarily in the Z axis at higher frequencies beyond 20 Hz. The only exception may include any substantial air turbulence that could cause low frequency vibration below 10 Hz. Otherwise, the two tested prototype cushions present similar or less vertical axis vibration entering the occupant as compared to the standard jet aircraft cushion.

Figure 27. Transmissibility Magnitude

Figure 28. Transmissibility Phase





3.8 Sled Testing

The measured resultant lumbar loads are less than the injury criteria for a 95%ile subject (Figure 29).

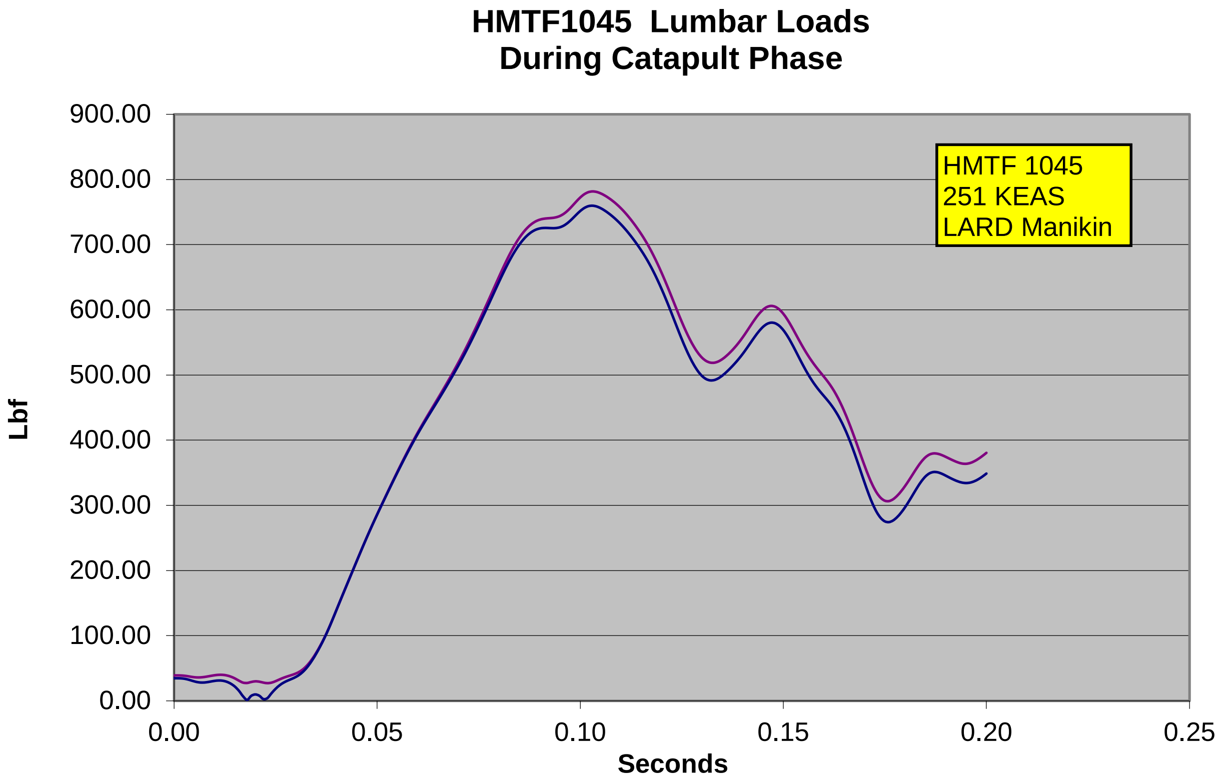


Figure 29. Resultant Lumbar Loads During Sled Test

3.9 Flight Testing

Based on the limited evaluation, the AFFTC concluded the air bladder seat cushion is suitable for further in-field evaluation in operational aircraft.

> "Overall, the performance of the new AFRL active air bladder ACES II seat cushion in the F-16 aircraft was satisfactory. The AFRL seat cushion was easy to use and operate. Aircrew acceptance and comfort suitability were also satisfactory. Some concerns were expressed about the inflating and deflating of the air bladders being distracting during critical phases of flight, but the power on/off switch was easily accessed and turned off if desired. However, none of the distractions were significant enough to cause the pilot to turn the seat off.
>
> Although this testing effort did not involve the long duration missions for which the AFRL active air bladder ACES II seat cushion was designed, the concept was demonstrated successfully and gained aircrew acceptance. **Based on this limited evaluation, the AFRL active air bladder ACES II seat cushion is suitable for conducting further in-field evaluation in operational aircraft."** (Gutierrez & Berggren, 2009).

The complete results are documented in the flight test report from the Edwards AFB flight test center (Gutierrez & Berggren, 2009).

As part of the interim safe to fly, a test hazard analysis was conducted with no outstanding issues identified (Appendix H).

4.0 CONCLUSION

Advanced prototype seat cushions were developed and tested to a draft specification to deliver increased comfort and performance to Airmen in confined environments while maintaining safety. Research efforts included multi-hour comfort testing of cushions, environmental, anthropometric accommodation, impact testing to ensure safety, ejection sled testing, modeling, and developmental flight testing. The Goodrich AIP air bladder cushion was shown to be comfortable for long duration missions and safe in an ejection environment. Follow-on operational testing in aircraft during long duration sorties should be considered.

REFERENCES

Arnegard R. J. (1991), "Operator Strategies Under Varying Conditions of Workload." National Aeronautics and Space Administration, Langley Research Center, NASA CR-4385, 1991.

Arnegard R. J. and Comstock JR (1991), "Multi-attribute Task Battery: Applications in Pilot Workload and Strategic Behavior Research." *Proceedings of the Sixth International Symposium on Aviation Psychology,* Columbus, Ohio, April, 1991, 1118-1123.

Bennett L. (1984), "Skin Stress and Blood Flow in Sitting Paraplegic Patients." *Arch. Phys. Med.Rehabil.*, Vol 65, April 1984.

Brinkley J. W., Perry C. E., Orzech M. A., and Salerno M. D. (1993), "Evaluation of Proposed F-4 Ejection Seat Cushion By +Gz Impact Tests." AL/CF-TR-1993-0160, Armstrong Laboratory, Wright-Patterson AFB OH, July, 1993.

Caldwell J. A., Ramspott S., Gardner S. J. (1998), "The Impact of Task Length on Multi-Attribute Task Battery Performance During Sleep Deprivation." USAARL-98-10, Fort Rucker, AL, Jan 1998.

Caldwell J. A., Smythe N. K., Hall K., and Norman D. (1999), "The Effects of Modafinil on Aviator Performance During 40 Hours of Continuous Wakefulness: A UH-60 Helicopter Simulator Study." USAARL-99-17, Fort Rucker, AL, Jun 1999.

Cantor A. (1974), "Live Qualification of the Lumbar Pad and Pulsating Seat Cushion for the S-3A Escape System." NADC-74031-40, Naval Air Development System (NADC), Warminster, PA, 1974.

Carmody M. A. (1994), Task-Dependent Effects of Automation: The Role of Internal Models in Performance, Workload, and Situational Awareness in a Semi-Automated Cockpit, NAWCADAWAR-94140-60, Warminster, PA, Mar 1994.

Cheng Z. Q., Rizer A. L., and Pellettiere J. A. (2002a), "Characterization of Impact Properties of Ejection Seat Cushions." Proceedings of the 2002 Annual SAFE Meeting, 2002.

Cheng Z.Q., Rizer A. L., and Pellettiere J. A. (2002b), "Limiting Performance of Ejection Seat Cushions for Spinal Injury Reduction." Proceedings of the 2002 ASMA Annual Scientific Meeting.

Cheng Z. Q. and Pellettiere J. A. (2003), "Computational Analysis of Ejection Seat Cushions for Optimal Control of Spinal Injuries." SAE Paper No. 2003-01-3001.

Cheng Z. Q., Rizer A. L., and Pellettiere J. A. (2003), "Characterization of Ejection Seat Cushions by a Quasi-Linear Visco-Elastic Model." Proceedings of 4th International Conference on Time-Dependent Materials, October 2003, NY.

Cheng Z. Q. and Pellettiere J. A. (2004a), "Analysis of the Safety Performance of Ejection Seat Cushions." Proceedings of the 2004 Annual SAFE Meeting, September, 2004, UT.

Cheng Z. Q. and Pellettiere J. A. (2004b), "Modeling and Identification of Foam-Based Ejection Seat Cushions." Proceedings of SEM X International Congress & Exposition on Experimental and Applied Mechanics, June 2004, CA.

Cheng Z. Q. and Pellettiere J. A. (2005), " Investigations of the Performance of Ejection Seat Cushions for Safety and Comfort." SAE Paper No 2005-01-3263.

Cheng Z. Q., Smith J., Pellettiere J. A., and Fleming S. M. (2007), "Considerations and Experiences in Developing an FE Buttock Model for Seating Comfort Analysis." SAE Paper No 2007-01-2458.

Cohen D. (1998), "An Objective Measure of Seat Comfort, Aviation Space Environmental Medicine." 1998; 69:410-4.

Comstock J. R. and Arnegard R. J. (1992), "The Multi-Attribute Task Battery for Human Operator Workload and Strategic Behavior Research." NASA Technical Memorandum 104174, January 1992.

Dennis M. R. and Mandel P. H. (1992), "Improved Comfort, Safety, and Communications for Aviators, Re-Thinking the Man-Machine Interface." Oregon Aero, Inc. Aloha, Oregon, December 5, 1992.

Darvish K., Cheng Z. Q., Smith J., and Pellettiere J. A. (2008), "Viscoelastic Properties and Finite Element Modeling of Human Flesh." Proceedings of the International Conference of Applied Human Factors and Ergonomics, Las Vegas, NV, 2008.

Desjardins S. P. and Laananen D. H. (1979), "Aircraft Crash Survival Design Guide: Volume IV – Aircraft seats, restraints, litters, and padding." USARTL-TR-79-22D, Fort Eustis, VA: Applied Technology Laboratory.

Ferguson-Pell M. W. and Cardi M. (1992a), "Pressure Mapping Systems for Seating and Positioning Applications: Technical and Clinical Performance." Helen Hayes Hospital, Center for Rehab Technology, RESNA International '92, June 6-11, 1992, 219-221.

Ferguson-Pell M. W. and Cardi M. (1992b), "Pressure Mapping Systems," Team Rehab Report, October, 1992, 27-32.

Gutierrez M. C. and Berggren M. M. (2009),"Air Force Research Laboratory (AFRL) Active Air Bladder Advanced Concept Ejection Seat (ACES II) Seat Cushion Flight Test and Evaluation." AFFTC-TR-09-60, Edwards AFB, CA.

Hearon B. F. and Brinkley J. W. (1986), "Effect of Seat Cushions on Human Response to +Gz Impact." *Aviation Space Environmental Medicine*, 1986; 57:113-21.

Henderson J. L., Price S., Brandstater M., and Mandac B. (1994), "Efficacy of Three Measures to Relieve Pressure in Seated Persons With Spinal Cord Injury." *Arch. Phys. Med. Rehabil*., Vol **75**, May 1994.

Jex H. R., McDonnell J. D., and Phatak A. V. (1966), "Critical Tracking Task for Manual Control Research." *IEEE Transactions on Human Factors*, HFE-7, 138-145, 1966.

LeDuc P. A. and Caldwell J. A. (1998), "The Effects of Exercise as a Countermeasure for Fatigue in Sleep Deprived Aviators." USAARL-98-35, Fort Rucker, AL, Aug 1998.

Critical Instability Tracking Test: Operators Manual. Once available from Systems Research Laboratories, 301 Airport Drive; California, Maryland, 20619, 1985.

Improved Seat Comfort for Extended Missions, H. Koch & Sons, Inc., SBIR Phase1 Interim Report #002, Contract F41624-99-C-6042, 30 July 99.

Oudenhuijzen A. J. K. (2007). Comfort and Discomfort Assessment of Several Seat Cushions in F16 Ejection Seats. TNO Report, TNO, 2005.

Parakkat J., Pellettiere J. A., Reynolds D., Sasidharan M., and El-Zogbi M. (2006), "Quantitative Methods for Determining U.S. Air Force Crew Cushion Comfort." AFRL-HE-WP-TR-2006-0092, Wright-Patterson AFB, OH, 2006.

Pellettiere J. A. and Cheng Z. Q. (2004), "Development of an Optimized Seat Cushion Design Methodology." Proceedings of the Fourth Triennial International Aircraft Fire and Cabin Safety Research Conference, Lisbon, Portugal, November 2004.

Pellettiere J. A., Parakkat J., Reynolds D., Sasidharan M., and El-Zogbi M. (2006), "The Effects of Ejection Seat Cushion Design on Physical Fatigue and Cognitive Performance." AFRL-HE-WP-TR-2006-0163, Wright-Patterson AFB, OH, 2006.

Pellettiere J. A. and Cheng Z. Q. (2007), "Digital Human Modeling with Applications." Proceedings of the Fifth Triennial International Aircraft Fire and Cabin Safety Research Conference, Atlantic City, NJ, November 2007.

Pellettiere J. A., McHenry B. G., Hu J., and Yang K. H. (2008), "The Appropriateness and Applicability of Occupant Modeling and Simulation." Proceedings of the International Conference of Applied Human Factors and Ergonomics, Las Vegas, NV, 2008.

Perry C. E. (1997), "Evaluation of a Proposed B-2 Seat Cushion by +Gz Impact." AL/CF-TR-1997-0112, Armstrong Laboratory, Wright Patterson AFB OH, February 1997.

Perry C. E., Nguyen T. Q., and Pint S. M. (2000), "Evaluation of Proposed Seat Cushions to Vertical Impact." SAFE Association Symposium Proceedings, Reno, NV, 2000.

Pint S. M. (1999), Internal Memorandum, ACESII Seat Cushion Comfort Interview with LtCol Lex Brown, AFRL/HEC, 2 Aug 99.

Pint S. M., Pellettiere J. A., and Coate J. E. (2000),"Determination of Seat Cushion Mechanical Properties." Proceedings of the 2000 Annual SAFE Meeting, 2000.

Pint S. M., Pellettiere J. A., and Nguyen C. (2002), "Development of Objective Test Methods for Determination of Ejection Seat Cushion Comfort." SAFE Association Symposium Proceedings, 2002.

Shields R. K. and Cook T. M. (1992), "Lumbar Support Thickness: Effect on Seated Buttock Pressure in Individuals with and without Spinal Cord Injury." Physical Therapy, 73:2, March 1992.

Segal T. (1987), "Pilot Safety and Spinal Injury." Lasham Gliding Society England, *Presented at the XX OSTIV Congress*, Benalia, Australia, Volume XII, No. 4, 1987.

Smith S. D. and Jurcsisn J. G. (2010), "Cushion Effects During low Frequency Jet Aircraft Vibration Exposure." AFRL-RH-WP-TR-2010-0080, Wright-Patterson AFB, OH, 2010.

Severance C. M. (1997), "B-2 Aircrew Seat Comfort Cushion Design and Development." Northrop Grumman Corporation, Palmdale, CA, SAFE Association Conference Proceedings 1997, 25-32.

Stubbs J. E., Pellettiere JA, and Pint SM (2005), "Quantitative Method for Determining Cushion Comfort." SAE 2005 Transaction Journal of Passenger Cars: Mechanical Systems, SAE Paper No 2005-01-1005.

VanIngen-Dunn C. and Richards M. K. (1992), "Feasibility of Reducing Incidence of Low Back Pain in Helicopter Pilots Using Improved Crewseat Cushions." AL-SR-1991-0009, Armstrong Laboratory, Wright-Patterson AFB OH, December 1992.

ACRONYMS

DRI	Dynamic Response Index
VDT	Vertical Deceleration Tower
AFRL	Air Force Research Laboratory
AIP	Aircraft Interior Products
BIA	Bioelectrical Impedance Analysis
WSU	Wright State University
MATB	Multi-Attribute Task Battery
LOIS	Lightest Occupant in Service
LARD	Large Anthropomorphic Research Device
DAS	Data Acquisition System
LPD	Local Perceived Discomfort
EMI	Electromagnetic Interference
RM ANOVA	Repeated Measures Analysis of Variance
AFFTC	Air Force Flight Test Center
ACES	Advanced Concept Ejection Seat
HMTF	Hurricane Mesa Test Facility

APPENDIX A: Draft Cushion Specification

AFRL/HEPA 0001

September 2006

SYSTEM REQUIREMENTS DOCUMENT (SRD)
SEAT CUSHION

Table of Contents

1.0 SCOPE

This specification states the performance and verification requirements for ejection seat cushion assemblies.

1.1 Description

The goal of this Air Force Ejection Seat Cushion Assembly Performance Specification is to increase aircrew combat effectiveness through production of a seat cushion assembly that will provide safe and comfortable seating conditions for extended missions without degrading occupant performance while operating in the specified aircraft mission environment.

The ejection seat cushion assembly shall accommodate the full size range of the USAF Pilots (AFI 48-123). The weight range is 103 lbs. to 245 lbs. (nude weight). When the occupant is seated with the restraint system properly fastened, the seat cushion assembly shall self-contour to the occupant's body, providing optimal spinal and lumbar alignment, aircrew comfort and safety protection during normal flight, emergencies, and emergency ejection.

The ejection seat cushion assembly shall also accommodate the full size range of the USAF Pilots (AFI 48-123) during ejection and shall keep the Dynamic Response Index (DRI) of the seat system/cushion below 18 for ACES II seat applications. The weight range is 103 lbs. to 245 lbs. (nude weight). The seat cushion assembly shall not change the CG of the seat occupant and the eye position must stay the same or better.

The seat cushion assembly shall provide equal distribution of pressure to the occupant/cushion contact area and shall not bottom out (completely compresses to the point it no longer isolates the occupant from the hardness of the seat) during extended missions, maneuvers, emergencies or ejection. The seat cushion assembly shall have provisions for being retained to the ejection seat, preventing displacement of the cushion during aircraft maneuvers, occupant motion, ejection, and a crash.

The seat cushion assembly shall be flame resistant, self-extinguishing, and produce only low smoke density with minimal amounts of toxic fumes when exposed to flames. The seat cushion assembly shall be easily removed for maintenance purposes without the need for special tools.

The phrase "seat cushion assembly" in this specification refers to the entire seat cushion system, to include all upholstered covers and sub assemblies including the seat back pad assembly, the seat bottom cushion assembly, and the lumbar pad if applicable. This specification applies to the seat cushion assembly in its entirety. Human Engineering as prescribed by MIL-STD-1472 will be adhered to in the design and manufacture of seat cushion assemblies.

2.0 Applicable Documents

2.1 General

2.2 Government Documents

2.2.1 Specifications, Standards and Handbooks

The following specifications, standards and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the applicable issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto.

2.2.1.1 Federal Standards

FED-STD-595: Colors Used in Government Procurement

(Copies of this document are available online at http://assist.daps.dla.mil/quicksearch/ or www.dodssp.daps.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Department of Defense

MIL-STD-129: Marking For Shipment and Storage

MIL-STD-130: Identification Marking of U.S. Military Property

MIL-STD-810: Environmental Engineering Considerations and Laboratory Tests

MIL-STD-2073: DOD Standard Practice for Military Packaging

MIL-STD-1472F: Human Engineering

(Copies of this document are available online at http://assist.daps.dla.mil/quicksearch/ or www.dodssp.daps.mil or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.3 Other Government publications

Federal Aviation Regulation (FAR) 23.562: Emergency Landing Dynamic Conditions

Federal Aviation Regulation (FAR) 25.853: FAA Air Worthiness Standards, Fire Protection

Publications can be attained from www.access.gpo.gov or US National Archives and Records Administration, 700 Pennsylvania Ave. NW, Washington, DC 20408

2.3 Non-Government Publications

2.3.1 American Association of Textile Chemist and Colorists

AATCC 8-2001	Colorfastness to Crocking
AATCC 16-2003	Colorfastness to Light (Fading)
AATCC 76-2000	Electrical Resistivity of Fabrics

(Copies of these documents are available from www.AATCC.ORG or AATCC, P.O. Box 12215, Research Triangle Park, NC 27709

2.3.2 American Society for Testing and Materials

ASTM D 1683-04 Standard Test Method for Failure in Sewn Seams of Woven Apparel Fabrics

ASTM D 2261-96 Standard Test Method for Tearing Strength of Fabrics by the Tongue (Single Rip) Procedure (Constant-Rate-of-Extension Tensile Testing Machine)

ASTM D 3511-02 Standard Test Method for Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Brush Pilling Tester (Surface Wear)

ASTM D 4157-02 Standard Test Method for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder Method)

ASTM D 5034-95 Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)

(Copies of these documents are available from the American Society for Testing and Materials International, 100 Barr Harbor Drive, West Conshohocken, PA 119428-2959.)

2.4 Other Publications

Boeing Specification Support Standard 7238: Test Method for Smoke Generation by Materials on Combustion

Boeing Specification Support Standard 7239: Test Method for Toxic Gas Generation by Materials on Combustion

(Copies can be attained from http://www.global.ihs.com)

2.5 Order of Precedence

In the event of a conflict between the text of this document and the applicable documents cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3.0 SYSTEM REQUIREMENTS

3.1.1 Inspections

3.1.1.1 First article

When specified, samples shall be subjected to a first article inspection in accordance with 4.2.1.

3.1.1.2 Conformance

When specified, samples shall be subjected to a conformance inspection in accordance with para 4.2.2.

3.2 Materials

Materials used in the manufacture of the seat cushion shall be of high quality and not degrade cushion performance or safety when exposed to the cushion operational and storage environments specified in para 3.12.2.3.1. Materials used shall meet or exceed both the specified service life and storage life. The contractor shall select materials capable of meeting all of the operational and environmental requirements specified herein.

3.3. Recycled, recovered or environmentally preferable materials

Recycled, recovered or environmentally preferable materials should be used wherever possible, provided the material meets or exceeds the requirements of Section 3 of this specification and promotes economically advantageous life cycle costs.

3.4 Comfort

The seat cushion assembly shall provide continuous comfort and shall not bottom out (completely compresses to the point it no longer isolates the occupant from the hardness of the seat) during extended missions. When the occupant is seated with the restraint system properly fastened, the seat cushion assembly shall self-contour to the occupant's body, providing optimal spinal and lumbar alignment, aircrew comfort and safety protection during normal flight, emergencies, and emergency ejection.

3.4.1 Compression Load

The seat bottom cushion assembly shall not bottom out during extended missions.

3.4.2 Pressure Distribution

The seat cushion assembly shall contour to the occupant, providing a natural pressure distribution.

3.4.3 Spinal Alignment

The seat cushion assembly shall promote natural spinal alignment, resulting in a comfortable seating condition when the occupant is seated with the seat restraint system properly fastened. To accomplish this, the radius of the lumbar spine shall be 22-27 cm.

3.4.4 Crash Loads

Based on the weight of a 250 pound occupant, the seat cushion assembly shall transmit less than 2,206 pounds of compression between the pelvis and the lumbar spine area when dynamically tested in accordance with the Emergency Landing Dynamic Conditions Test.

3.5 Anthropometry Accommodation

The ejection seat cushion assembly shall accommodate the full size range of the USAF Pilots (AFI 48-123) and shall keep the Dynamic Response Index (DRI) of the seat system/cushion below 18 for ACES II seat applications. The weight range is 103 lbs. to 245 lbs. (nude weight). The seat cushion assembly shall not change the CG of the seat occupant. Accommodation in terms of the occupant's eye position, overhead clearance, ejection clearance, reach to rudder pedals, and reach to controls must stay the same or improve compared to the current seat cushion assembly.

3.6 Ejection Vertical Impact Loads

The acceleration imposed on the seat occupant and cushion assembly in the +Gz direction (parallel to the spinal column) during ejection shall be limited in terms of the Dynamic Response Index (DRI) values calculated according to the method described in Appendix A. The DRI value for the seat/seat cushion assembly shall be less than 18 for ACES II equipped aircraft. Dynamic loads transferred from the seat cushion assembly to the occupant's lumbar area shall meet the requirements specified in 4.6 for the ACES II Ejection Seats.

3.7 Parts Interchangeability

Seat cushion assemblies and sub-assemblies, including removable upholstery covers, with the same manufacturer's part number shall be functionally and dimensionally interchangeable.

3.8 Form, Fit, Function and Integration

The seat cushion assembly shall be a form, fit, and function replacement of the original seat cushion assembly and shall not obstruct ingress or egress, or cause interference with aircrew duties in the cockpit.

3.9 Color

The seat cushion assembly upholstery shall be either Sage Green or Black per FED-STD-595. Slight variances in color due to lot differences are acceptable.

3.10 Seat Cushion Assembly Envelope

Each individual seat cushion assembly shall meet the specific dimensions and seat interface requirements for its aircraft seat application in accordance with the respective seat cushion envelope drawing/data in

.

Table -1: Seat Cushion Assembly Envelope Data

F-16	SEAT BOTTOM CUSHION	SEAT BACK CUSHION	Lumbar Pad
	Reference Drawing J119126 Attachment points for Interfacing Seat Hardware, Installation/Accommodations, Snap Fastener Locations, Identification Labels TBD	Reference Drawing J114917 Thickness, Attachment points for Interfacing Seat Hardware, Installation/Accommodations, Snap Fastener Locations, Labels TBD Reinforced Stitching Areas TBD	Dimensions, Velcro attach points TBD
	Reinforced Stitching Areas TBD	Oxygen Hose Flap Locations TBD Velcro Riser Strap Holder Locations TBD	
	Zipper Location TBD Dimensions Length, Width, Height, TBD	Location and Dimensions of Other Misc Seat Interface TBD	
	Dimensions/Location of Leg/Stick Cutout TBD Minimum Cushion Height when compressed with distributed weight of 250lb occupant TBD		

3.11 Seat Cushion Assembly Weight

The seat cushion assembly and subassemblies shall weigh no more than the threshold of 8 lbs. distributed across the seat bottom and back reflected in Table 3-2 below.

Table -2-2: Ejection Seat Cushion Assembly/Subassembly Weights

Aircraft Seat	Back Pad Weight	Bottom Cushion Weight	Lumbar Pad Weight

ACES II	3.0 lbs Maximum	4.0 lbs Maximum	1.0 lbs Maximum

3.12 Product Quality

3.12.1 Service Life

The seat cushion assembly shall meet all Section 3 requirements, operate as designed by the original seat and cushion manufacturer, and provide occupant comfort and protection for a minimum service life of three years when used within the specified environments. The seat cushion assembly shall maintain its functional and physical integrity, and shall maintain at least 80% of its original overall height across the entire cushion throughout its service life.

3.12.2 Storage Life

The seat cushion assembly shall have a minimum storage life of six years.

3.12.3 Combined Storage/Service Life

The combined storage life/service life of the seat cushion assembly shall be a minimum of six (6) years. For example, if a cushion is removed from storage and put into service after four years, it shall then have a minimum of two years of service life remaining.

3.12.1.1 Low Flammability

The upholstery material used in the seat cushion assembly shall be inherently flame resistant and self-extinguishing.

3.12.1.2 Low Smoke Density

The upholstery material used in the seat cushion assembly shall be of a type that produces low density smoke when burned or exposed to flames, allowing the crewmember(s) time to take emergency actions.

3.12.1.3 Low Toxicity

The upholstery material used in the seat cushion assembly shall be of a type that produces low toxic fumes when burned or exposed to flames, allowing the crewmember(s) time to take emergency actions.

3.12.1.4 Electrical Surface Resistivity

To minimize static charge buildup, the seat cushion upholstery material shall have an electrical surface resistivity between 1M and 10M ohms per square at 12% relative humidity and 72˚F to help reduce static charge buildup.

3.12.1.5.1 Solar Radiation Resistance

To meet the minimum service life of three years specified in para 3.9.1, the seat cushion assembly upholstery material shall be resistant to solar radiation. Minor fading is acceptable. Physical and functional degradation of material is not acceptable.

3.12.1.5.2 Crocking Resistance (Colorfastness)

The seat cushion assembly upholstery material shall be resistant to fading caused by contact with other materials during normal and emergency use. Minor fading is acceptable. Physical and functional degradation of material is not acceptable.

3.12.1.5.3 Pilling Resistance

The seat cushion assembly upholstery material shall be resistant to pilling. Light to moderate pilling is acceptable.

3.12.1.5.4 Abrasion Resistance

The seat cushion assembly upholstery material shall be resistant to abrasion.

3.12.1.5.5 Breaking Strength

The seat cushion assembly upholstery material shall be resistant to breakage.

3.12.1.5.6 Tear Strength

The seat cushion assembly upholstery material shall be resistant to tearing.

3.12.1.5.7 Yarn Slippage Resistance

The seat cushion assembly upholstery material shall be resistant to yarn slippage.

3.12.2.1 Retention

The seat cushion assembly shall remain firmly attached to the seat under all normal and emergency operations. The seat cushion retention device(s) shall interface with the seat without any modification to the seat.

3.12.2.2 Maintainability and Repair

The seat cushion assembly shall be replaceable without the use of special tools and without removal of the seat from the aircraft. All seat cushion assembly maintenance, including cleaning, shall be done at field level.

3.12.2.3 Environmental Conditions

The seat cushion assembly shall function without degradation in performance after being exposed to the environmental conditions specified below.

3.12.2.3.1 Storage/Operational Temperature

The seat cushion assembly shall withstand a storage temperature range of -65˚F to +160˚F and an operating temperature range of -40˚F to +130˚F.

3.12.2.3.2 Humidity

The seat cushion assembly shall withstand exposure to a condition of 95% relative humidity at +140˚F.

3.12.2.3.3 Fungi

The materials used in the seat cushion and cover assembly shall not provide nutrients for fungi.

3.12.2.3.4 Salt Fog/Corrosion

Seat cushion assembly hardware, such as snap fasteners and zippers, shall be corrosion-resistant, capable of withstanding atmospheric conditions, including salt spray, likely to be encountered during storage or normal operational service. Dissimilar metals are prohibited unless they are specifically treated for protection against electrolytic corrosion.

3.12.2.3.5 Sand and Dust

The seat cushion assembly shall withstand exposure to a sand and dust environment.

3.12.4 Labeling

The seat cushion assembly shall be labeled and permanently marked on the upholstery cover assemblies with the following information in accordance with MIL-STD-130. The marking shall be impregnated in black lettering with no less than 3/16 inch or greater than 5/16 inch in height and centered on the bottom cover of the seat cushion assembly.

- Manufacturer's Name and Cage Code
- Manufacturer's Part Number
- Issue Date
- Air Force Part Number
- Contract No.

4.0 VERIFICATION

Pass/Fail of the service life and environmental tests shall be verified through completion of successive compression tests, upholstery tests, comfort tests, crash load tests, and vertical drop tower tests. Therefore, recommend the following successive testing order:

1. Service Life Verification
2. Environmental Tests
3. Compression Test
4. Upholstery Tests
5. Comfort Tests
6. Crash Load Tests
7. Vertical Drop Tower Tests
8. Cushion Assembly Flame Impingement Test

4.1.2 Government Notification

The contractor shall notify the Government procuring activity at least 14 days in advance of the start of any verification.

4.2.1 First Article

First article inspection shall be performed on completed seat cushion assemblies when first article samples are required. This inspection shall include the verification of para 4.5 through para 4.10.3.

4.2.2 Conformance

A conformance inspection shall include the sample size of para 4.2.2.2 and the examination of para 4.3.

NOTE: This is a critical life support item; sampling inspections shall not be waived

4.2.2.1 Sampling for Inspection.

4.2.2.2 Sample seat cushion assemblies shall be selected at random from each lot on the same production order, in the quantities specified below.

- A minimum of one seat cushion assembly randomly from each lot of 1-100.
- A minimum of two seat cushion assemblies from each lot of 101-200. One randomly from the first 100 and one randomly from the second group of 100.
- A minimum of one seat cushion randomly from each group of 100 from lots of 100-500.
- For lots greater than 500, a minimum of one seat cushion assembly randomly from each additional lot of 100 or fraction thereof.

4.3 Examination

Each seat cushion assembly shall be examined for compliance with the requirements specified in Section 3. They shall be free of visible defects or any other imperfections. Noncompliance with any specified requirement or the presence of one or more defects shall constitute cause for rejection of the lot.

4.4 Comfort

Verification of the comfort requirement shall be verified by all of the following:

Compression Load testing (para 4.4.1)

Pressure Distribution mapping (para 4.4.2)

Spinal Alignment testing (para 4.4.3)

Comfort Survey (Appendix D)

Note: the Comfort Survey will be conducted by the Government or its representative.

4.4.1 Compression Load

Verification of the compression load requirement shall be by test. Using a Government approved 250 lb Anthropometric Test Device (ATD), the seat bottom cushion shall be subjected to the 250 lb compression load test specified in Table-1. After one hour, the cushion shall be examined to determine how much it has compressed while still under the 250 lb compression load. To meet this requirement, the cushion shall retain at least 50% of its original uncompressed height across the entire cushion at 70° nominal temperature.

Table -3: Seat Bottom Cushion Test

Application Area	Load Center	Load Direction	Proof Load (Lbs)	Proof Load Duration)
Seat Bottom Cushion	ATD or Test Subject	Down	250	15 Minutes

4.4.2 Pressure Distribution

The pressure distribution requirement shall be verified by test using standard pressure data collection methods. Given a 250 pound occupant, the seat bottom cushion shall distribute the occupant's weight so that a threshold pressure of 2.5 psi is not exceeded and with the objective pressure of 2.0 psi that exists at any contact point.

4.4.3 Spinal Alignment

Verification of proper spinal alignment shall be verified by test. Standard industry practices for acquiring lumbar spinal alignment data include, but are not limited to, 3D surface scanning, radiographic imaging and Shape Tape.

4.5 Anthropometry Accommodation

The Anthropometry Accommodation shall be verified by test.

The ejection seat cushion assembly shall accommodate the full size range of the USAF Pilots (AFI 48-123) and shall keep the Dynamic Response Index (DRI) of the seat system/cushion below 18 for ACES II seat applications. The weight range is 103 lbs. to 245 lbs. (nude weight). The seat cushion assembly shall not change the CG of the seat occupant. The occupant's eye position, overhead clearance and ejection clearance must stay the same or better as provided by the current seat cushion assembly. This shall be verified by measuring and comparing the relative position of human subjects in both the existing seat cushion assembly as well as the proposed seat cushion assembly. Human subjects must represent the weight range of USAF pilots.

4.6 Ejection Vertical Impact Loads

The Ejection Vertical Impact Loads shall be verified by test.

Note: the following is a short synopsis of how vertical drop tower tests have been conducted by the Air Force Research Laboratory at Wright Patterson AFB Ohio. Testing is accomplished with a vertical deceleration tower using the appropriate size Anthropometric Test Device (Manikin), restrained to an aircraft specific seat, impact carriage, and test seat cushion. Sensors attached to the manikin, seat, impact carriage and test seat cushion are base-lined prior to testing through a calibration run which is used to set the limits of the sensors and equipment. The test facility consists of a 60 foot vertical steel tower, which supports a guide rail system, an impact carriage supporting plunger, and a hydraulic deceleration device. The impact carriage is raised to a maximum height of 39 feet prior to release. After release, the carriage free falls until the plunger, attached to the undercarriage of the seat, enters a water-filled cylinder mounted at the base of the tower. The manikin experiences a deceleration impulse as the plunger displaces water in the cylinder. The deceleration profile is determined by the free fall distance, the carriage and test specimen mass, the shape of the plunger, and the size of the cylinder orifice. A rubber bumper is used to absorb the final impact as the carriage stops. The nominal drop height for a 12G test is 14 feet 6 inches. An accelerometer captures G load data where it is attached to the lumbar area of the seat. The accelerometers are adjusted for the effects of gravity through software by adding the component of a 1G vector line with the force of gravity that lies along the accelerometer axis. Measurements from the load cells are taken at the seat contact point. Note: the seat/seat cushion DRI shall be less than 18 on all ACES II equipped aircraft.

ACES II

5th Percentile: Less than 1,000 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

50th Percentile: Less than 1,500 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

95th Percentile: Less than 2,200 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

4.7 Parts Interchangeability

Verification shall be by inspection and analysis.

4.8 Form, Fit, Function and Integration

Verification of form, fit, function and integration shall be by inspection and demonstration. A sample seat cushion assembly of each aircraft seat configuration shall be installed into the respective aircraft to verify its form, fit, function and integration. A representative aircrew member, utilizing the seat restraint system, shall operate the seat through its entire range of adjustments. The crewmember shall demonstrate his/her ability to perform all required mission duties without the seat cushion assembly interfering with the performance of cockpit duties. The aircrew member shall also demonstrate ingress and egress without seat cushion assembly interference.

4.9 Color

Color verification shall be by inspection.

4.10 Seat Cushion Assembly Envelope

Verification of the seat cushion assembly envelope shall be by inspection.

4.11 Seat Cushion Assembly Weight

Verification of the seat cushion assembly weight shall be by inspection using a calibrated scale.

4.12 Product Quality

4.12.1 Service Life

The service life shall be verified by conducting the following test:

The seat bottom cushion shall be subjected to 140,000 jounce cycles and 7,000 squirm cycles at room temperature with a form device applying a force of 200 pounds. An appropriate representative seat base assembly shall be used to mount the cushion for testing. The form device shall be jounced at 90 cycles per minute and squirmed at 4 cycles per minute. At the completion of this test, there shall be no visible material breakdown, including separation between attached materials. In addition, the seat bottom cushion shall maintain at least 80% of its original overall height across the entire cushion and shall pass all of the following:

1 – The cushion comfort tests para 4.4.1 through para 4.4.3

2 – The comfort survey questionnaire in Appendix D

3 - The crash load test para 4.4.4

4 - The vertical drop tower tests of para 4.4.5

4.12.2 Storage Life

The seat cushion assembly storage life shall be verified by analysis, extrapolating from data collected during the following tests:

1 – The service life testing in para 4.12.1

2 – The high and low temperature tests in para 4.12.2.3.1.1 and para 4.12.2.3.1.2

3 – The humidity test in para 4.12.2.3.2

4.12.3 Combined Storage/Service Life

The combined storage/service life shall be verified by analysis.

4.12.1.1 Low Flammability

Verification of low flammability shall be by test. A minimum of three samples of the upholstery materials used in the seat cushion assembly shall be used during flammability testing. These samples shall be cut from a test cushion(s) that has completed the service life tests in para 4.12.1 and the environmental tests in para 4.12.2.3. The Twelve Second Burn Test procedures specified in FAR 25.853, Appendix F, Part I, shall be used to test the flammability of the upholstery material samples. Prior to flammability testing, the upholstery samples shall be laundered or dry-cleaned; whichever is applicable, 10 times. The materials shall meet the USAF vertical burn test requirements listed in Table 4-1 in order to pass this test. Results of all test samples shall be reported individually and averaged for all conditions.

Table 4-1: Twelve Second Vertical Burn Test Requirements

After flame time	0.0 sec, max avg
Burn length	3.5 in, max avg
After flame time of dripping	0.0 sec, max avg
After glow time	0.0 sec, max avg

4.12.1.2 Low Smoke Density

Verification of low smoke density shall be by test. A minimum of three samples of the upholstery materials used in the seat cushion assembly shall be tested for smoke density under flaming conditions for four minutes in accordance with the test procedures contained in Boeing Specification Support Standard BSS 7238. The specific optical smoke density (Ds) shall not

exceed 200 after four minutes of flame exposure to materials. These samples shall be cut from a test cushion(s) that has completed the service life tests in para 4.9.1 and the environmental tests in para 4.12.2.3.

4.12.1.3 Low Toxicity

Verification of low toxicity shall be by test. A minimum of two samples of the upholstery materials used in the seat cushion assembly shall be cut from a test cushion(s) that has completed the service life tests in para 4.12.1 and the environmental tests in para 4.12.2.3. The samples shall be tested for toxic gas generating characteristics IAW the procedures and equipment referenced in Boeing Specification Support Standard BSS 7239. For toxic gases testing, use below.

Table -4-2 Toxic Gases Test

GASES	LIMITS @ FOUR MINUTES FLAMING
CO	100 PPM
HCN	20 PPM
NO+NO2	10 PPM
SO2	5 PPM
HCL	50 PPM
HF	50 PPM

4.12.1.4 Electrical Surface Resistivity

The electrical surface resistivity shall be verified by test IAW AATCC-76-2000.

4.12.1.5.1 Solar Radiation Resistance

Verification of solar radiation resistance shall be by test. The seat cushion upholstery material shall be tested IAW MIL-STD-810F, Method 505.4 Procedure II. Pass criteria for this test shall be the successful completion of the tests in para 4.12.1.5.4 through para 4.12.1.5.6.

4.12.1.5.2 Crocking Resistance (Colorfastness)

Verification of crocking resistance (colorfastness) shall be by test. The seat cushion upholstery material shall be tested IAW AATCC 8. Grade 4 is the acceptable minimum dry. Grade 3 is the acceptable minimum wet.

4.12.1.5.3 Pilling Resistance

Verification of pilling resistance shall be by test. The seat cushion upholstery material shall be tested IAW ASTM D 3511. Level 3 is the acceptable minimum.

4.12.1.5.4 Abrasion Resistance

Verification of abrasion resistance shall be by test. The seat cushion upholstery material shall be tested IAW ASTM D 4157-02, Oscillatory Cylinder Method, 50,000 double rubs, #10 cotton duck, option 1. Two end breaks constitute a failure.

4.12.1.5.5 Breaking Strength

Verification of breaking strength shall be by test. The seat cushion upholstery shall be tested IAW ASTM D 5034 to ensure a minimum breaking force of 222 Newtons (N), (50 lbf).

4.12.1.5.6 Tear Strength

Verification of tear strength shall be by test. The seat cushion assembly upholstery shall be tested IAW ASTM D 2261-96 to ensure a minimum tearing force of 27 Newtons (N), (6 lbf).

4.12.1.5.7 Yarn Slippage Resistance

Verification of yarn slippage resistance shall be by test. The seat cushion upholstery material shall be tested IAW ASTM D 1683 to ensure a minimum yarn slippage of 111 Newtons (N), (25 lbf).

4.12.2.1 Retention

Verification of the retention requirement shall be by demonstration.

4.12.2.2 Maintainability and Repair

Verification of the maintainability and repair requirement shall be by demonstration.

4.12.2.3 Environmental Conditions

4.12.2.3.1 Storage/Operational Temperature

Verification of the storage/operational temperature requirement shall be by test as described below.

4.12.2.3.1.1 High Temperature

The seat cushion assembly shall be subjected to MIL-STD-810F, Method 501.4, Procedures I and II.

The seat cushion assembly shall be subjected to a non-operating (storage) high temperature exposure in Table 501.4-II (Induced Conditions) for seven 24-hour cycles. After the seat cushion assembly returns to ambient temperature, the functionality of the seat cushion assembly shall be verified by the test method in para 4.4.1.

For the operational high temperature exposure, the seat cushion assembly shall be subjected to a minimum of three 24-hour cycles. While at the extreme temperature of the third cycle, the functionality of the seat cushion assembly shall be verified by the test method in para 4.4.1.

4.12.2.3.1.2 Low Temperature

The seat cushion assembly shall be subjected to MIL-STD-810F, Method 502.4, Procedures I and II.

The seat cushion assembly shall be subjected to a non-operating (storage) low temperature exposure of -65°F according to Procedure I for 72 hours. After the seat cushion assembly returns to ambient temperature, the functionality of the seat cushion assembly shall be verified by the test method in para 4.4.1.

For the operational low temperature exposure, the seat cushion assembly shall be subjected to -40°F according to Procedure II for a minimum of 2 hours. While at the extreme temperature, the functionality of the seat cushion assembly shall be verified by the test method in para 4.4.1.

4.12.2.3.2 Humidity

Verification of the humidity requirement shall be by test. The seat cushion assembly shall be tested IAW MIL-STD-810F, Method 507.4. The operational checkout referred to in Method 507.4.

Note: the humidity test shall be performed prior to the salt fog, sand and dust, or fungus tests if the same test article is used for these tests.

4.12.2.3.3 Fungi

Verification of the fungi requirement shall be by test. The seat cushion assembly shall be tested IAW MIL-STD-810F, Method 508.5. Appropriate species of test fungi (U.S. Standard) shall be used, as listed in Table 508.5-I. Test duration shall be 28 days minimum, or a maximum of 84 days for a degree of less risk, to determine the effects of fungi on the seat cushion and cover assembly.

4.12.2.3.4 Salt Fog/Corrosion

Verification of the salt fog/corrosion requirement shall be by test. The seat cushion assembly shall be tested IAW MIL-STD- 810F, Method 509.4. After exposure to this test, there shall be no evidence of corrosion.

4.12.2.3.5 Sand and Dust Testing

Verification of the sand and dust requirement shall be by test. The seat cushion assembly shall be tested IAW MIL-STD-810F, Method 510.4, Procedures I and II.

4.12.4 Labeling

The seat cushion and cover assembly shall be labeled according to MIL-STD-130. Verification of compliance shall be by inspection.

4.12.5 Requirement/Verification Method/Verification Requirement

Requirement	Verification Method	Verification Requirement
3.8 Form, Fit, Function and integration	Demonstration	4.8
3.9 Color	Inspection	4.9
3.10 Seat Cushion Assembly Envelope	Inspection	4.10
3.11 Seat Cushion Assembly Weight	Inspection	4.11
3.12.1 Service Life	Test	4.12.1
3.12.2 Storage Life	Analysis	4.12.2
3.12.3 Combined Storage/ Service Life	Analysis	4.12.3
3.12.1.1 Low Flammability	Test	4.12.1.1
3.12.1.2 Low Smoke Density	Test	4.12.1.2
3.12.1.3 Low Toxicity	Test	4.12.1.3
3.12.1.4 Electrical Surface Resistivity	Test	4.12.1.4
3.12.1.5.1 Solar Radiation Resistance	Test	4.12.1.5.1
3.12.1.5.2 Crocking Resistance (Colorfastness)	Test	4.12.1.5.2
3.12.1.5.3 Pilling Resistance	Test	4.12.1.5.3
3.12.1.5.4 Abrasion Resistance	Test	4.12.1.5.4
3.12.1.5.5 Breaking Strength	Test	4.12.1.5.5

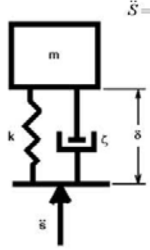
Requirement	Verification Method	Verification Requirement
3.12.1.5.6 Tear Strength	Test	4.12.1.5.6
3.12.1.5.7 Yarn Slippage	Test	4.12.1.5.7
3.12.2.1 Retention	Demonstration	4.12.2.1
3.12.2.2. Maintainability and Repair	Demonstration	4.12.2.2
3.12.2.3.1 Storage/Operational Temperature	Test	4.12.2.3.1
3.12.2.3.2 Humidity	Test	4.12.2.3.2
3.12.2.3.3 Fungi	Test	4.12.2.3.3
3.12.2.3.4 Salt Fog/Corrosion	Test	4.12.2.3.4
3.12.2.3.5 Sand and Dust	Test	4.12.2.3.5
3.4.1 Compression Load	Test	4.4.1
3.4.2 Pressure Distribution	Test	4.4.2
3.4.3 Spinal Alignment	Test	4.4.3
3.4.4 Crash Loads	Test	4.4.4
3.6 Ejection Vertical Impact Loads	Test	4.4.5
3.12.1.1 Low Flammability	Test	4.12.1.1
3.12.4 Labeling	Inspection	4.12.4

Appendix A

Determination of Dynamic Response Index (DRI)

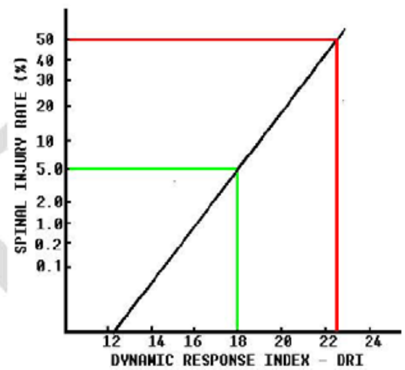
Note: The seat cushion assembly DRI shall be calculated using accelerometer measurements taken from the top of the seat cushion assembly during vertical drop tower testing.

The DRI is representative of the maximum dynamic compression of the vertebral column of the human body. In physical terms, the DRI is calculated by mathematically describing the human body in terms of an analogous, lumped parameter mechanical model consisting of a mass, spring, and damper. The DRI is determined from the equation below:



$$\ddot{S} = \ddot{\delta} + 2\zeta\omega_n\dot{\delta} + \omega_n^2\delta$$

$$DR(t) = \frac{\omega_n^2\delta(t)}{g}$$



$\ddot{\delta}$ is the acceleration of the dynamic response model mass relative to the Critical Point acceleration (unit of acceleration).

$\dot{\delta}$ is the relative velocity between the Critical Point and the model mass (unit of velocity).

δ is the compression of the model spring (unit of displacement).

ζ is the damping coefficient ratio

ωn is the undamped natural frequency of the model

$\ddot{S}$ is the acceleration component along the pertinent axis acting at the Critical Point (unit of acceleration).

g is the acceleration due to gravity (gravitational constant consistent with above units).

(t) indicates that the parameter is determined as a function of time.

Appendix B

Rationale for the maximum lumbar load.

The dynamic test lumbar spinal load of 2206 pounds in para 3.4.4 was calculated based on the Federal Aviation Administration's maximum load of 1500 pounds for a 170 pound occupant. The number was scaled up to be commensurate with the seat cushion assembly specification requirement for a 250 pound occupant using the following formula:

$$\frac{1500 \text{ lb} \times 250 \text{ lb}}{170 \text{ lb}} = 2206 \text{ lb}$$

Appendix C

FLIGHT TESTING FOR THE SEAT CUSHION COMFORT SURVEY

This survey was developed to aid in objectively determining the level of comfort and performance of proposed new aircrew seat cushions. The survey will allow the ultimate user of the cushion, the aircrew to assess and have an input to the qualification and approval process of proposed aircrew seat cushions.

This testing shall be required for all vendors submitting new designed seat cushion assemblies for qualification testing. Each new proposed aircrew seat cushion shall be flight tested on the appropriate airframe as follows:

1. A minimum of two proposed seat cushions shall be provided by the vendor for testing.
2. A total of 10 individual crewmembers shall fly missions with these cushions.
3. At least one mission of long duration (8-10 hours) shall be flown by the ten aircrew.
4. At least 10 missions of short duration (1.0-1.5 hours) shall be flown by the ten aircrew

At the completion of each flight a survey questionnaire shall be completed by the crewmember. A score of 6 and above on a rating scale of 1 through 10 shall be attained for the seat cushion assembly to pass the comfort test.

Table C-1: Required Test Assets

Airframe Designators	Number of Pilots per Airframe	Number of Aircraft per Airframe	Seat Cushion Assemblies required per Airframe	Mission-Long Duration	Mission-Short Duration
See Table 3-2	10	2	1	8-10 Hours	1.0 - 1.5 Hours

Note: If an airframe has multiple model designations and there are variations to the seat assembly they shall be required to be flight tested per this Table.

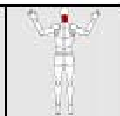
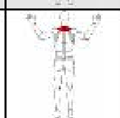
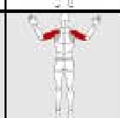
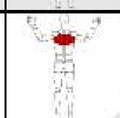
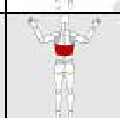
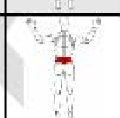
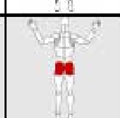
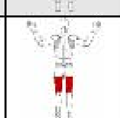
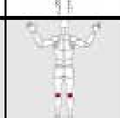
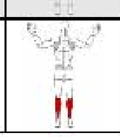
APPENDIX D

SEAT CUSHION COMFORT SURVEY

SEAT CUSHION DISCOMFORT SURVEY

Directions: Please fill out the following survey after completing each flight. Provide any written comments regarding your discomfort or likes/dislikes of the cushion on the reverse side of this form. Mail all completed surveys to 311 HSW/YA---, Attn: ____________, Brooks AFB, TX 78235-5352 or FAX to 210-536-____ or DSN 240-______.

Name		Date		Aircraft	
Stature (in)		Test No.		Flight Duration (min)	
Weight (lbs)		Cushion ID			
Sit Height (in)		Signature			

Body Part and Location		Discomfort Scale (Circle scale to indicate intensity for each body part) None … Moderate … Unbearable	What type of sensation is causing your discomfort? (Check all that apply)	
Neck		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Shoulder		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Upper Arms		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Upper Back		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Mid Back		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Lower Back		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Buttocks		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Thighs		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Knees		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other
Lower Legs		0 1 2 3 4 5 6 7 8 9 10	❑ Ache ❑ Burning ❑ Tingling	❑ Sharp Pain ❑ Numbness ❑ Other

Feet		0 1 2 3 4 5 6 7 8 9 10	☐ Ache ☐ Sharp Pain ☐ Burning ☐ Numbness ☐ Tingling ☐ Other

APPENDIX B: DHM Modeling Paper

2007-01-2458

Considerations and Experiences in Developing an FE Buttock Model for Seating Comfort Analysis

Zhiqing Cheng and Jeanne A. Smith
General Dynamics Advanced Information Systems
5200 Springfield Pike Suite 200, Dayton, OH 45431-1289

Joseph A. Pellettiere and Scott M. Fleming
Human Effectiveness Directorate, Air Force Research Laboratory
2800 Q Street, Wright-Patterson AFB, OH 45433-7947

ABSTRACT

The comfort of seat cushions has become important in many of today's high-performance USAF fighter and tactical aircraft. Experimental investigations have found that there exists a strong relationship between the human subjective discomfort rating for a seat cushion and the pressure distribution on the interface between the cushion and the buttocks. For the analysis of the contact pressure distribution, a finite element model of the human buttock was developed. The model consists of a detailed geometric description of the skin, soft tissues, and bony structures. The development of the model is described in this paper, which includes source data selection, bony structure modeling, joint modeling, soft tissue modeling, and pelvis shape morphing.

Introduction

With combat bomber crew missions during Operation Enduring Freedom reaching over forty hours in length, the crewmember sitting comfort has become increasingly important to many of today's high-performance USAF fighter and tactical aircraft. Comfort is critical to both physical endurance and combat effectiveness.

Ejection seat cushions in current U.S. Air Force aircraft are not adequate for comfort during extended missions [1, 2]. Specific physiological problems resulting from or related to the discomfort of seating involve pain in the buttocks, legs and back; numbness and tingling in the extremities; and overall fatigue. Whereas a sophisticated circulation-enhancing seating system could provide substantial improvements in occupant comfort, it has limited application to military aircraft seats, especially ejection seats, as they are an integral part of an aircraft life support system. The introduction of any complicated systems or additional parts to enhance comfort would require extensive integration and qualification efforts at considerable cost. Therefore, solutions for comfort that can be quickly and cost-effectively implemented are desired. Fortunately, long-term sitting comfort can be enhanced by a new or improved seat cushion. A number of cushion designs with new materials and configurations have been introduced recently for the improvement of comfort.

Comfort is a subjective feeling influenced by psychological, physiological, and physical factors. However, experimental investigations have found that there exists a strong relationship between the human subjective discomfort rating for a seat cushion and certain physical quantities of the pressure distribution on the interface between the cushion and the buttocks. These quantities include contact area, peak pressure, and the distribution center. The pressure distribution depends upon the cushion material and configuration. Thus, the comfort performance of a cushion can be improved by optimizing its material properties and configuration. Computational modeling and simulation of various designs can be an effective and efficient way to optimize the comfort performance of a cushion. A new design can be tested for its degree of comfort by computational simulations, which would reduce the amount of prototypes needed to introduce a new seat design. For the analysis of the contact pressure distribution, a finite element model of the human buttocks is required. The development of the model is described in this paper, which includes source data selection, bony structure modeling, joint modeling, soft tissue modeling, pelvis shape morphing, and model validation.

Experimental Investigations of Seating Comfort

To define the requirements for the FE human buttock model development, it is necessary and beneficial to have a review of recent seating comfort experimental investigations and the findings from them.

A series of cushion comfort tests were conducted at the Air Force Research Laboratory (AFRL) as a part of an overall effort to define seat cushion parameters that will maximize the comfort performance of a cushion without jeopardizing its safety performance. A pilot study was done in 1999 in which 5 males were monitored for a 4-hour sitting duration [3]. This study indicated the need for long-duration monitoring to gain a realistic understanding of the long-term effects on the operator's

responses. The pilot study also led to improvements for the first 8-hour sitting duration study conducted in 2003 in which a larger, more diverse subject panel was observed on 4 cushion types in an F-15 seat configuration [4]. The 2003 study revealed that correlations exist in objective seated pressures and subjective comfort levels. Based upon the previous studies, an expanded study was conducted in 2005 by introducing additional variables into tests, which included conventional cushions with static properties as well as new cushion designs with dynamic properties, increased measurement frequencies, and new measurement techniques [5]. These techniques included monitoring the change in lower extremity blood oxygen saturation levels to provide an estimation of blood flow behavior and monitoring low back and shoulder muscular fatigue. Blood pooling was selected for monitoring because periods of minimal to no motion in the leg in long-term flight could lead to deep vein thrombosis. Muscular fatigue levels in the low back and shoulder were selected to be monitored due to the long-duration effects of low-level sustained contractions. Combined, these factors were considered to be potentially significant contributors of discomfort during seated long-term flight.

The major findings and results from these tests can be summarized as follows.

- *Discomfort rating:* As in the cushion evaluation conducted by Stubbs et al. [4], it was expected that cushions with the lowest peak pressure points would show positive characteristics in subjective and objective tests and that cushions with the highest peak pressure points would show negative characteristics in the tests. For the static cushions, this proved to be the case for the correlation between average peak pressure and subjective discomfort survey ratings for the buttocks and thighs [5].
- *Task performance:* The results of task performance suggest that static cushion comfort does not have a negative impact on subject performance [4]; however, low dynamic cushion comfort may have a negative effect on the performance [5]. This leads to the conclusion that seat cushion comfort can be objectively measured, but its impact on the subject task performance is not very high.
- *Muscle fatigue:* For static cushions, trapezius muscle fatigue was exhibited throughout the 8-hour session for both male and female subjects but with varying time durations. The dynamic cushion elicited a unique response for both males and females due to the fact that no fatigue, and potentially recovery, occurred at every 2-hour interval. No measurable fatigue activity was present for the lumbar muscles for both static and dynamic cushions. This may be due to the lack of constraints placed on the assumed posture of the test subjects. More realistic aircraft scenarios with appropriate mobility restraints need to be investigated in future studies.
- *Oxygen saturation:* Although minimal changes of oxygen saturation and no differences between cushions were found for female subjects, males exhibited significantly decreased levels of oxygen saturation for all cushions. Motion and maintaining proper blood flow are necessary to mitigate long-term effects, such as the discomfort that the male subjects felt after standing. Monitoring oxygen saturation in the lower extremities is a relatively new modality for determining blood flow and pooling patterns. Oximeter data collection and processing techniques need further investigations.
- *Gender difference:* The differences in comfort preference and other objective measurements between genders were significant. Certain anthropometric factors such as body weight distribution may also cause the differences among test subjects.
- *Other factors:* Stress level, concentration level, and the micro-environment may have important effects on the comfort testing results, especially task performance scores.

Requirements and Considerations

In summary, the interface pressure distribution between the seat and human body is related to the seating discomfort. It can be readily measured from tests. It can also be obtained from computational simulation if the seat structure and the human subject are well modeled. While muscular fatigue and blood oxygen saturation are related to the seating discomfort, more investigations are needed to obtain consistent and definite relationships. They can be objectively measured in tests but cannot be readily determined from computational simulations, because in terms of the state-of-art of human modeling, it is very challenging to accurately model the stress/strain in muscles and blood flow in large regions of diverse tissues. The seating comfort varies with gender and certain human anthropometric factors related to seating contact area and sitting posture.

Several human models were developed in recent years for the analysis of seating comfort. Among them, an FE buttock model was developed using MADYMO [6]. The model includes a detailed anatomical description of the bony structures, such as iliac wings, sacrum, coccyx, and femora. The soft tissues, muscles, fat, and ligaments are lumped together and the skin is modeled separately. The geometry of the model is based on a post mortem human subject that was a 78-year-old male. One problem with using the model in ejection seat cushion comfort analysis is that the anthropometry of the model does not represent the US Air Force aircrew population. Since seating comfort is strongly related to the buttock soft tissues, the variation of buttock tissues with age could lead to large discrepancy in comfort requirements between the young and the old. Another problem is that the limited validation of the model prevents readily using the model for practical applications. Another FE model reported in [7] was

developed based on the MRI scan data of a young, healthy male subject, intending to investigate stress-strain condition in deep tissues. The boundary conditions of the model were constrained corresponding to the particular loading conditions of the test subject and certain assumptions were used in the modeling. The model needs more validation and improvement. Since the seating comfort depends upon not only seat cushion but also backrest support, a full finite element occupant model was developed [8].The model is representative of a 50th percentile male in the sitting position and includes anatomically precise features such as leg and pelvic bones, hip joint ligaments, full spine, deformable thighs, hips and trunk. Inner organs and other outer body segments are modeled with rigid bodies linked with nonlinear kinematic joints. While the simulations of the model have achieved sound agreement with the tests of a small number of human subjects, the model lacks the flexibility to account for anthropometric variations and gender differences.

Therefore, we define reasonable requirements for the FE buttock model as follows:

- To be able to simulate the interface normal force (contact pressure distribution), interface shear force, and the stress in certain regions of human lower body;
- To be representative of the Air Force aircrew population, allowing for gender differences and anthropometric variations;
- To be able to consider various seating postures;
- To be generic, independent, and computationally efficient, leaving spaces for enhancement and expansion.

Model Development

Seating comfort modeling includes the modeling of the seat structure (seat cushion) and the modeling of the human subject. The modeling of a seat structure using FE is straightforward. The major task of static cushion modeling is the determination of cushion material properties. The modeling of a dynamic cushion may be more involved as the mechanism of a dynamic cushion needs to be properly described. The modeling of the human subject is a complex task and is the focus of this study.

For seating comfort analysis, usually only the buttocks and the upper legs that are in contact with the seat are modeled in detail. The rest of the body can be considered as rigid and can be described by a rigid multi-body model.

Source Data Selection

One open source of human anatomical data is the Visible Human Dataset from the National Library of Medicine, National Institute of Health. (http://www.nlm.nih.gov/research/visible/visible_human.html). While this dataset provides a complete visual insight of the entire human body, it is totally unstructured and static. Large efforts are needed to create an FE human model from the dataset. With the time limit and condition restraints, we chose to use other data resources available to us to build the model to meet basic requirements for the seating comfort analysis. These include:

- *VAKHUM (Virtual Animation of the Kinematics of the Human) Database:* http://www.ulb.ac.be/project/vakhum/public_dataset/public-data.htm Sponsored by European Commission, it is an open source for non-commercial use. The database has the data for bony structures only. The data of soft tissues and skin are not available.
- *CAESAR (Civilian American and European Surface Anthropometry Resource) Database:* It contains anthropometric variability of men and women, ages 18-65. Using three-dimensional (3D) laser scanning technology, human body anthropometric surface data were collected for each person in a standing pose, full-coverage pose and relaxed seating pose.
- *In-house Human Body Scan Data:* The data were collected at the AFRL on human subjects using a 3D laser scanner. If necessary, the data can be readily collected on a particular subject.

Model Geometric Construction

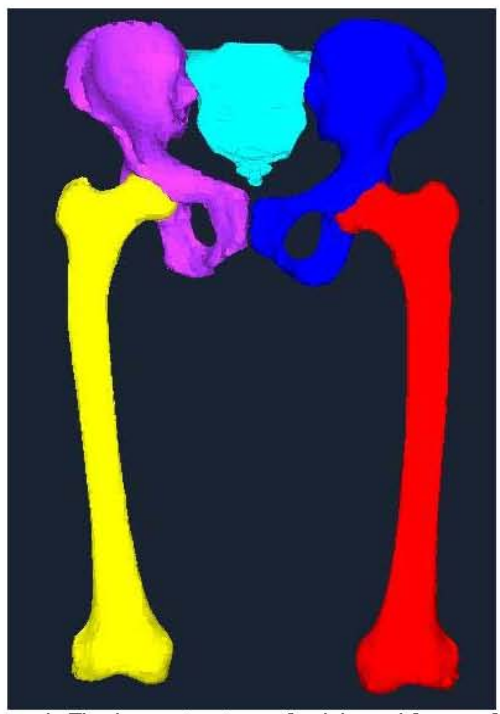


Figure 1. The bony structure of pelvis and femurs from the VAKHUM

The bony structure is primarily drawn from the VAKHUM database and approximately represents a 50th percentile male. As shown in shown in Fig.1, it includes the pelvis (sacrum, coccyx, ilium, pubis, and ischium) and femurs.

The bony structure is modeled with solid elements and is assumed to be rigid, as the deformation of soft tissues is the primary factor in the comfort problem. Since the sacrum and coccyx directly meshed from the volume data from VAKHUM were more complex than needed, a simplified sacrum-coccyx component was created and meshed with solid elements, as shown in Fig. 2.

Spherical joints, a joint type provided in LS-DYNA, have been applied between the iliac wings and the upper body, and between each iliac wing and femora (hip joints). The implementation of hip joints is to allow for the investigation of various sitting postures. By rotating the femur bones about the hip joints, the bony structure in a sitting posture is generated, as shown in Fig. 3.

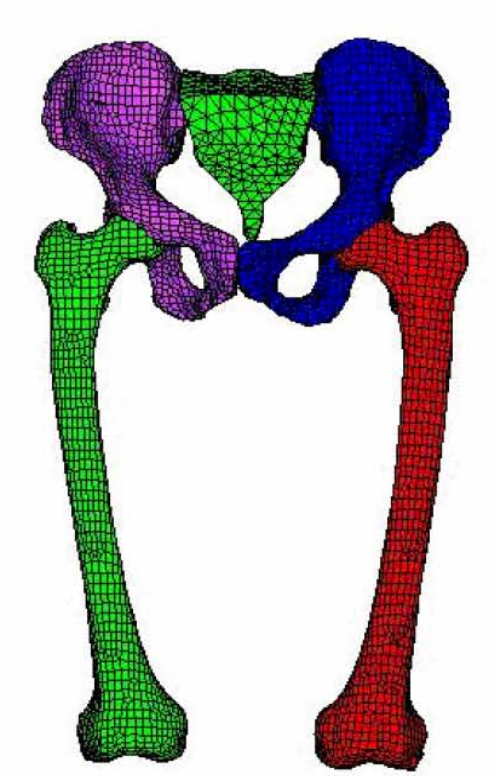


Figure 2. Solid-meshed bony structure with simplified sacrum-coccyx

Based on an in-house dataset, the outer skin shape was taken from a 3D anthropometric scan of a human male subject, approximately 50th percentile, in a standing position as shown in Fig. 4. The scan was cut just above the waist and just below the lateral epicondyles at the knees. The landmarks used for the bispinous breadth and bitrochanteric breadth anthropometric measurements projected slightly above the skin surface, and so were visible in the scan data. These measurements were used in scaling and positioning the bones and outer surface.

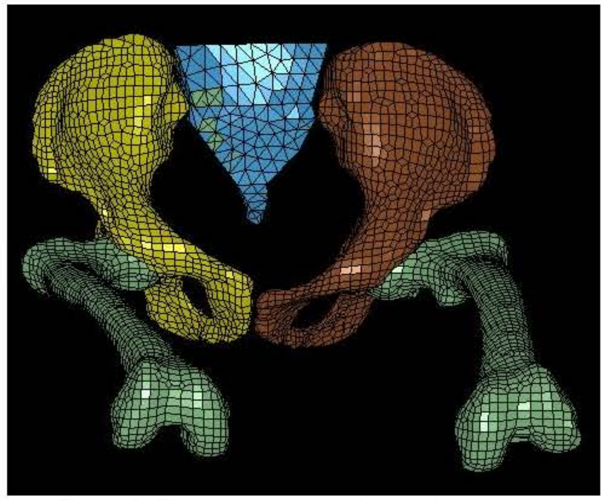


Figure 3. The bony structure in a sitting posture

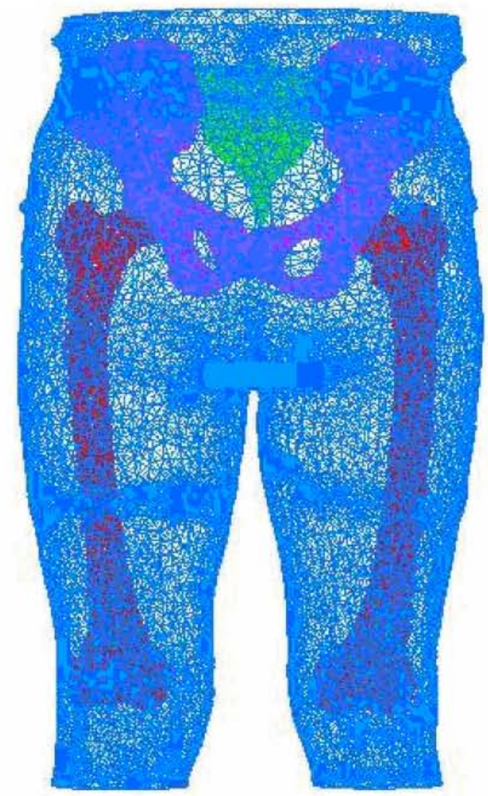


Figure 4.Three-dimensional anthropometric scan of a male subject (standing position)

For the analysis of seating comfort, the model needs to describe the human subject in a seated position. It is desirable to use a 3D scan of a seated human to generate the seated shape. However, the 3D scan surface of the same subject in a sitting position is not complete, as shown in Fig 5, because body surfaces

hidden by the seat or by other body parts are not included. However, using the seated scan dimensions can approximate the changes in body shape from the standing to the seated position. The standing scan surface was modified to approximate the seated scan, including rotation of the legs.

Instead of modeling the buttock soft tissues according to detail anatomical data, the fat, muscles, and ligaments are lumped together and are described by layers of solid elements. The soft tissue modeling started with the thigh, due to the relatively simple geometry. A cone, truncated at both ends and sized to a slightly smaller diameter than the outer "skin", was created from lines, then meshed with shell elements using HyperMesh from Altair Engineering. The volume of the cone was meshed with layers of solid elements to fill the space as much as possible down to the femur. Then the outer shell layer of the soft tissue cone was morphed to the 3D scan surface. It was necessary to create regular-shaped layers of solid elements before morphing because the process of adding layers does not work well after morphing. The inside of the soft tissue was morphed to the surface of the femur shaft, making certain nodes of soft tissue elements coincide with the nodes of femur solid elements. This worked well at the distal end, but left a gap at the proximal end because of its larger diameter. Manual adjusting was used to improve the soft tissue fill at the proximal end.

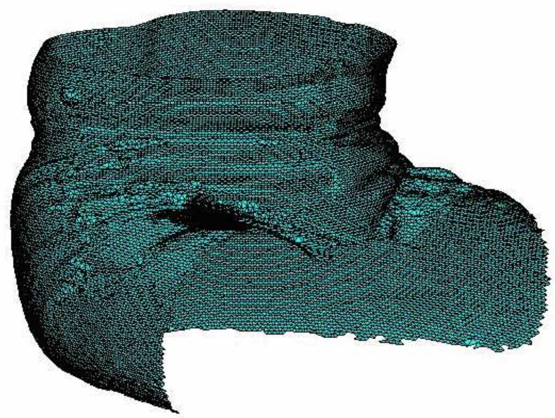


Figure 5. Three-dimensional anthropometric scan of a male subject (seated position)

For the pelvic volume, the soft tissue creation was more complex. Due to the irregular shape of the pelvis bony structure, the space between the outer skin and the bones is more complicated than the thigh. Many commercial FE meshing tools are unable to generate or recognize the volume of the spaces of this kind and thus automatic mesh generation becomes impossible.

Two methods can be used to overcome this difficulty. One is to create the volume by a Boolean subtraction of the bone volumes from the 3D scan surface volume in the buttock region. This was accomplished using Pro/ENGINEER. The entire volume was further segmented into several sub-volumes with simple shapes and then imported to HyperMesh and solid meshed.

Another method is to divide the entire space into two regions—anterior side and posterior side, and to treat them differently. The viscera filling the anterior side of the pelvis contains organs with fluids. It is more easily deformed and moved. Therefore, it can be modeled with shell-element bags of viscous fluid, or with SPH elements in LS-DYNA. The posterior buttock region, which plays a more important role than the anterior region in the seating comfort, needs to be modeled in detail with solid elements. This was done by segmenting the region into several sub-regions and then meshing each sub-region manually.

Material Properties

The material properties of the model are initially taken from values in the open literature. The bony structure is assumed to be rigid. Thus Material Type 20 in LS-DYNA is chosen with the parameters of Young's modulus $E = 10$ GPa, Poisson's ratio $\mu = 0.3$, and mass density $\rho = (1.1 \sim 1.2)\times 10^3$ kg/m^3, which varies slightly with each bone part. The skin is described by a linear elastic isotropic material model (Material Type 1 in LS-DYNA), with the parameters of $E = 0.85$ MPa, $\mu = 0.46$, and $\rho = 1.1\times 10^3$ kg/m^3 [6,9]. For the soft tissues, Mooney-Rivlin hyperelastic isotropic material model (Material Type 27 in LS-DYNA) is used. According to the description of this material model [10], the parameters are chosen as $A_1 = 1.65$ kPa, $B = 3.35$ kPa, and $\mu = 0.49$, and thus $C = 4.175$ kPa, and $D = 51.225$ kPa. For each layer of soft tissues, these values are allowed to vary in a small range.

Model validation

The model is still under construction. The completed model will be validated by comparing simulation results with test data.

Concluding Remarks

The comfort performance of a cushion can be improved by optimizing its material properties and configuration. Computational modeling and simulation of various designs can be an effective and efficient way to optimize the comfort performance of a cushion.

Whereas an FE human buttock model was developed in this paper, more work on the model is to be done in order to use it for practical applications, which includes the model validation, modification, and refinement. To scale the base model, especially the buttock outer shape to represent a particular test subject according to his or

her 3D laser scan data, is one of our interests and will be investigated in the future.

References

1 Cohen, D., An Objective Measure of Seat Comfort, *Aviation Space Environmental Medicine*, 1998; 69:410-4.

2 Severance, C.M., B-2 Aircrew Seat Comfort Cushion Design and Development, Northrop Grumman Corporation, Palmdale, CA, *SAFE Association Symposium Proceedings*, 1997, 25-32.

3 Pint, S.M., Pellettiere, J.A., Nguyen, C., "Development of Objective Test Methods for Determination of Ejection Seat Cushion Comfort," SAFE Association Conference Proceedings, 2002.

4 Stubbs, J., Pellettiere, J.A., and Pint, S.M. "Quantitative Method for Determining Cushion Comfort," Paper # 2005-01-1005, Society of Automotive Engineers (SAE), 2005.

5 Julia Parakkat, Joseph Pellettiere, David Reynolds, Manikandan Sasidharan, and Muhamed El-Zoghbi, Quantitative Methods for Determining US Air Force Crew Cushion Comfort, SAE paper 2006-01-2339, SAE 2006 Digital Human Modeling Conference, Lyon, France, 2006.

6 M.M Verver, J. Van Hoof, C.W.J. Oomens, J.S.H.M. Wismans, and F.P.T. Baaijens, A Finite Element Model of the Human Buttocks for Prediction of Seat Pressure Distributions, *Computer Methods in Biomechanics and Biomedical Engineering*, Vol. 7 No.4, August 2004, pp. 193-203.

7 Q. Sun, F. Lin, S. Al-Saeede, L. Ruberte, E. Nam, R. Hendrix, and M. Makhsous, Finite Element Modeling of Human Buttock-Thigh Tissue in a Seated Posture, Proceedings of 2005 Summer Bioengineering Conference, June 22-26, Vail, Colorado.

8 N. Montmayeur, C. Marca, H. Choi, and S. Sah, Experimental and Numerical analysis of Seating Pressure Distribution Patterns, SAE paper 2005-01-2703, SAE 2005 Digital Human Modeling Conference, Iowa city, Iowa, June 2005.

9 P.G. Agache, C. Monncur, J.I. Leveque, and J. De Rigal, Mechanical Properties and Young's Modulus of human Skin in Vivo, Archives of Dermatological Research, Vol. 269 No. 3, pp 221-232, 1980.

10 J.O. Hallquist, LS-DYNA Theoretical Manual, LSTC, 1998.

APPENDIX C: OPERATIONS AND MAINTENANCE MANUAL

1.0 INTRODUCTION

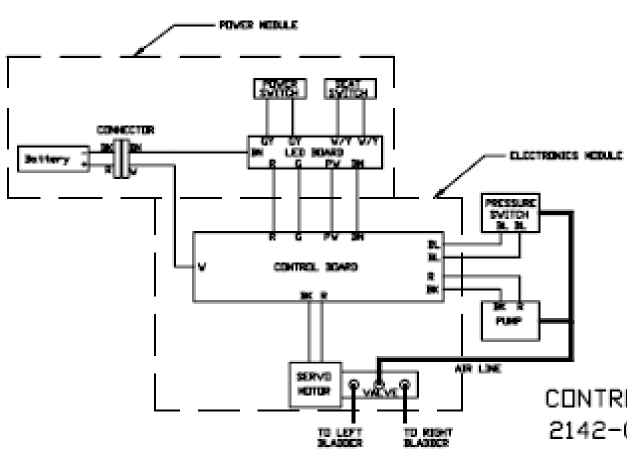
1.1 This is the Operations and Maintenance instructions for the ACES II Seat Cushion Enhancement Program. The purpose of this is to explain the cushion's operations and provide maintenance instructions.

2.0 CUSHION DESCRIPTION

2.1 The 8A2106-1 seat pan cushions are fabricated from the standard ACES II seat cushion J119126-501E. The J119126-501E seat cushion is then retrofitted with the dynamic pneumatic cushions into an 8A2106-1 per the 8A2106-1 Goodrich Drawing. The following components were used to make the new dynamic pneumatic cushions:

- ACES II Seat Pan Cushion PN: J119126-501E (make from)
- Bladder Assembly, PN: 1124-002-0000
- Accumulator, PN: 1124-006-0000
- Electronics Module*, PN: 1124-004-0000
- Pump Unit, PN: 5160-001-0000
- Power Module*, PN: 1124-005-0000
- Battery Pack, PN: 1124-007-0000
- Seat Switch, PN: 5130-001-0000
- Pressure Switch, PN: 5130-002-0000
- Modified Seat Cushion, PN: 1114-001-0000
- Restrictor, PN: 6110-001-0000

* The Electronic and Power Module control diagram is shown below:
EASE drawing 2142-002-0000 and Goodrich drawing 8A2106-1 define the basic envelope of the seat cushion assembly. All detail part drawings of the dynamic pneumatic components are proprietary to EASE Seating Systems. In the future, the Air Force may simply place a PO with Goodrich for PN: 8A2106-1 Cushion Assembly.



CONTROL BLOCK DIAGRAM
2142-001-0000

3.0 CUSHION OPERATION

3.1 The cushion is designed to be a self powered unit and is completely independent of any other systems in the aircraft. The new 8A2106-1 Cushion is one for one interchangeable with the existing J119126-501E Seat cushion. The removal and installation of the cushion is identical to the existing ACES II Seat cushion in T.O. 13A5-68-2.

3.2 To operate the cushion, the following steps are required:

a. Sit in the seat (The system incorporates a series of pressure switches that are activated by sitting on the cushion. The cushion will not operate without a pilot in the seat)
b. Pull tab on the left corner of the clearance cut-out to expose the “On/Off” switch and monitor lights
c. Push the toggle switch forward to the “On” position. There will be a “Green” light glowing to the right of the switch. After approximately 3 seconds the system will begin operating.
d. If upon turning the switch “On” the red and green lights flash alternately, the battery pack needs to be replaced

4.0 CUSHION MAINTENANCE

4.1 The only maintenance action is the removal and replacement of the batteries and cleaning and inspection of sheepskin cover. Any other maintenance issue requires replacement of cushion.

WARNING:

REPLACE BATTERY PACK WITH FACTORY SUPPLIED BATTERY PACKS. DO NOT SUBSTITUTE ANY OTHER BATTERY.

4.2 Changing the battery pack is accomplished by performing the following tasks:

a. Remove cushion from the seat I.A.W. T.O. 13A5-68-2, paragraph 5-148
b. Remove outer sheepskin cover to expose the innards of the cushion assembly
c. Remove inner cloth cover
d. The battery box cover is on the bottom side of the cushion at the base of the clearance cutout.
e. Remove the four (4) Phillips screws to open the box and remove the battery.

CAUTION:

When unplugging the battery connector, pull only on the connector, NOT the wires.

f. Replace the battery with a new pack and dispose of the old battery as a Hazardous Waste Product.

WARNING:

**These batteries are not rechargeable. At the risk of personal injury,
Do not attempt to recharge!**

g. Replace the pack in box and re-install the 4 screws in the assembly
h. Install inner cloth cover
i. Install sheepskin cover
j. Install seat cushion in seat I.A.W. T.O. 13A5-68-2, paragraph 5-152

4.3 Any cleaning and inspection of sheepskin cover will be I.A.W. T.O. 13A5-68-2.

4.4 Total battery life is expected to be approximately 50 hours. This 50 hours is actual running time. Therefore, if a cushion was to run for 1 minute every 5 minutes for an 8-hour duration, then the battery life could be expected to have approximately thirty-one 8-hour operating periods.

APPENDIX D: VDT TESTING 2009

<u>**SUMMARY TEST REPORT**</u>

BAA CUSHIONS FINAL IMPACTS:
VERTICAL IMPACT TEST RESULTS

STUDY NUMBER 200901

JANUARY 2009

Prepared in support of "Seat Interfaces for Aircrew Performance and Safety"
Under BAA 07-01-HE

711 HPW/RHPA
2800 Q Street
Wright-Patterson AFB, OH 45433-7947

Overview

A number of cushion designs with new materials and configurations have been introduced recently for the improvement of comfort. Therefore, when the comfort of a cushion design is assessed, its safety performance must also be considered. Prior to operational use in ejection seat aircraft, test data are needed to evaluate the cushions' safety performance and response to impact typical to that of an ejection. This program is needed to ensure safety is not compromised for comfort. Additionally, the findings from this program can be applied to a wider range of airframes, and seats.

This experimental effort involved a series of +Z axis impact tests on the Vertical Deceleration Tower (VDT) at Wright-Patterson Air Force Base, OH. Three manikins, a small female (LOIS), mid-sized male (50^{th} percentile Hybrid III Aerospace) and a large male (LARD) were used in this test program to simulate human response. Data collection consisted of manikin lumbar and cervical spine loads/forces and moments, head, chest and pelvis accelerations, shoulder straps and lap belt loads, seat pan and cushion accelerations, seat pan loads, carriage acceleration, carriage velocity, and high speed video. The data collected was used to support an objective analysis of the cushions' responses to impact.

This effort was funded by the Biomechanics Branch of the Air Force Research Laboratory (711 HPW/RHPA) and funded under Workunit 2830HP01. This effort is being conducted in support of AFRL/RHPA's Broad Agency Announcement, 07-01-HE, "Seat Interfaces for Aircrew Performance and Safety." All work was performed by InfoSciTex Corporation and The 711 HPW/RHAPA at Wright-Patterson AFB, OH.

Objectives

The primary objective of the effort was to evaluate the impact properties of the Phase I Production cushions from Goodrich and Oregon Aero to that of the baseline, factory-installed F-16 ACES II foam cushion (Goodrich). A secondary objective was to test 2 operational B-2 cushions that had recently been involved in an ejection.[1] The cushions tested are as follows:

- Cushion A: Baseline F-16 ACES II Foam Cushion (Goodrich)
- Cushion B: ACES II Cushion with EASE Bladders and C47 Foam (Goodrich)
- Cushion C: EPCT Foam Cushion (Oregon Aero)
- Cushion D: B-2 Operational Cushion (Oregon Aero) (Pilot)
- Cushion E: B-2 Operational Cushion (Oregon Aero) (Co-Pilot)

The critical issues addressed by this test program are as follows:

- Quantify the phase I production seat pan cushions' and B-2 cushions' responses to the listed acceleration levels.
- Compare the responses of the production seat pan cushions and B-2 cushions to that of the baseline cushion.
- Report the occupant risk implications associated with the phase I production cushions and B-2 cushions.

Background

Recent combat missions have reached more than 40 hours in length. Thus, it has become increasingly important that seat interfaces for aircrew be improved. Seat interface improvements are critical to enhance physical endurance and combat effectiveness of aircrew. Long-term sitting comfort may be enhanced by a new or improved seat cushion. However, some seat cushions have been shown to amplify the acceleration transmitted to the torso of the aircrew member if they have not been designed properly.[2] Any item introduced to an ejection seat and located between the seat pan and the gluteal region of the pilot must not compromise the existing risk of spinal injury which is limited by the human tolerance to the fracture of the lumbar vertebra. As more resources are applied to improving seat cushion comfort, the performance of a cushion for the prevention and reduction of spinal injuries (the safety performance) should not be compromised. The safety performance of a cushion can be measured by certain spinal injury criteria, such as Dynamic Response Index (DRI), or directly by certain occupant response characteristics, such as the peak lumbar load and the peak chest acceleration.[3,4] The evaluation of the safety performance of ejection seat cushions is conventionally performed using impact tests. A number of vertical deceleration tower (VDT) test studies have been performed at the Air Force Research Laboratory (AFRL) over decades to evaluate several types of ejection seat cushions, including certain designs with comfort improvement.[2,5-10]

Methods

InfoSciTex Corporation and The 711 HPW/RHAPA conducted the series of +Gz impact tests using the 711 HPW/RHPA Vertical Deceleration Tower (VDT) located in Building 824, Area B, at Wright-Patterson AFB, OH.

The VDT facility consists of a 60-foot vertical steel tower with a dual guide rail system, an impact carriage and attached plunger, a hydraulic deceleration device, and a test control and safety system (Figure 1). The plunger used for all tests on the VDT was plunger #102. To conduct a test, the carriage was allowed to enter a free-fall state (guided by the rails) from a pre-determined drop height. The plunger mounted on the rear of the carriage is guided into the hydraulic deceleration device (cylinder filled with water located at the base of the tower between the vertical rails). The displacement of water in the cylinder by the plunger produced an impact deceleration pulse. The pulse shape is controlled by varying the drop height, which determines the peak G level, and by varying the shape of the plunger, which determines the rise time of the pulse. A carriage-mounted seat is used to restrain the test manikin in an upright, seated position. The carriage, impact seat, and test manikin are instrumented with load cells or accelerometers to collect dynamic response data during the impact.

Figure 1. Vertical Deceleration Tower (VDT)

A modified ACES II F-16 ejection seat was used for all tests. The seat back was cut away from the seat and mounted to the VDT carriage so that the seat back tangent plane is vertical and in-line with the VDT rails. The seat pan was mounted to the horizontal surface of the VDT carriage so that the seat pan is perpendicular to the seat back tangent plane (Figure 2).

The manikins used in this study included a LOIS manikin (weighed 114 lb. as tested in flight suit, HGU-55/P medium helmet, MBU-20/P mask, and PCU-16/P harness), a Hybrid III 50th percentile aerospace (ballasted to weigh 180 lb. as tested in flight suit, HGU-55/P large helmet, MBU-20/P mask, and PCU-15/P harness), and a LARD manikin (weighed 247 lb. as tested in flight suit, HGU-55/P large helmet, MBU-20/P mask, and PCU-15/P harness). The 50th percentile manikin required approximately 10 lbs. of ballast to get to the target weight of 180

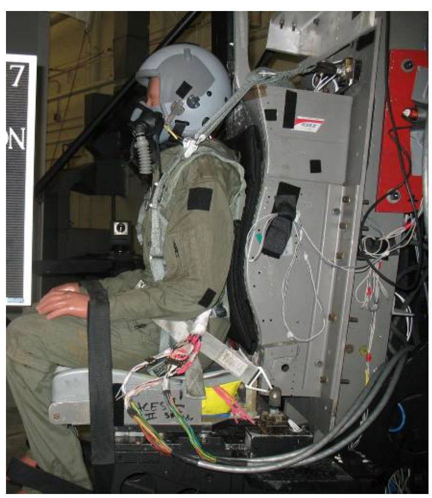


Figure 2. Seat Set-up

lbs., so a 10 lb. lead-pellet bag was placed within the floor of the pelvis.

The manikins wore a HGU-55/P helmet (medium or large), MBU-20/P mask with 3 in. hose, flight suit, and harness. The manikins were seated in an up-right position on the VDT seat and test cushion. A standard Oregon Aero ACES II seat back cushion was used for all tests. The manikins were centered in the seat and restrained using an ACES II lap belt. Parachute risers

were secured to the manikins' torso harness via Koch fittings. The parachute straps were routed over each shoulder and secured directly behind each shoulder at separate force load cells mounted to the carriage just behind the ACES II seat. This strapping method has been found to be much more effective in keeping VDT occupants in place during testing. The pre-tension levels of the lap belts and shoulder strap restraints were 20 ± 5 lbs. Velcro restraints were used to restrain the manikins' arms (wrists) and legs (ankles). See Figure 3.

Figure 3. LOIS, 50th percentile Aerospace Hybrid III, and LARD Manikins Secured in Seat

Thirty-two tests were conducted according to the test matrix (Table 1). Nine of these tests were done with the baseline factory installed ACES II F-16 cushion, four of these were done with the B-2 operational cushions, and the other 21 with Goodrich and Oregon Aero supplied phase I production cushions.

Table 1. Test Matrix

Cell	Cushion	Manikin	Level (G)	Cushion Type	Bladder Pressure	Test #
A	A	LARD	12	Goodrich F-16 ACES II Foam		5757
A	A	LARD	12	Goodrich F-16 ACES II Foam		5758
A	A	LARD	12	Goodrich F-16 ACES II Foam		5761
B	B	LARD	12	Goodrich C47 Air Bladder	Normal Operation	5762
B	B	LARD	12	Goodrich C47 Air Bladder	Normal Operation	5763
B	B	LARD	12	Goodrich C47 Air Bladder	Normal Operation	5764
B	B	LARD	12	Goodrich C47 Air Bladder	Normal Operation	5765
B	B	LARD	12	Goodrich C47 Air Bladder	Normal Operation	5766
C	C	LARD	12	Oregon Aero EPCT Foam		5759
C	C	LARD	12	Oregon Aero EPCT Foam		5760
E	A	50th HB3 Mod	12	Goodrich F-16 ACES II Foam		5756
E	A	50th HB3 Mod	12	Goodrich F-16 ACES II Foam		5767
E	A	50th HB3 Mod	12	Goodrich F-16 ACES II Foam		5768
E	A	50th HB3 Mod	12	Goodrich F-16 ACES II Foam		5769
F	B	50th HB3 Mod	12	Goodrich C47 Air Bladder	Normal Operation	5774
F	B	50th HB3 Mod	12	Goodrich C47 Air Bladder	Normal Operation	5775
F	B	50th HB3 Mod	12	Goodrich C47 Air Bladder	Normal Operation	5776

F	B	50th HB3 Mod	12	Goodrich C47 Air Bladder	Normal Operation	5777
G	C	50th HB3 Mod	12	Oregon Aero EPCT Foam		5778
G	C	50th HB3 Mod	12	Oregon Aero EPCT Foam		5779
H	D	50th HB3 Mod	12	B-2 Operational Cushion (Pilot)		5770
H	D	50th HB3 Mod	12	B-2 Operational Cushion (Pilot)		5771
H	E	50th HB3 Mod	12	B-2 Operational Cushion (Co-Pilot)		5772
H	E	50th HB3 Mod	12	B-2 Operational Cushion (Co-Pilot		5773
I	A	Lois	12	Goodrich F-16 ACES II Foam		5748
I	A	Lois	12	Goodrich F-16 ACES II Foam		5749
J	B	Lois	12	Goodrich C47 Air Bladder	Normal Operation	5752*
J	B	Lois	12	Goodrich C47 Air Bladder	Normal Operation	5753*
J	B	Lois	12	Goodrich C47 Air Bladder	Normal Operation	5754**
J	B	Lois	12	Goodrich C47 Air Bladder	Normal Operation	5755**
K	C	Lois	12	Oregon Aero EPCT Foam		5750
K	C	Lois	12	Oregon Aero EPCT Foam		5751

* The cushion was turned-on and the VDT carriage was dropped 6.5 minutes later.
** The cushion was turned-on and the VDT carriage was dropped 3.5 minutes later.

- Cushion A: Baseline F-16 ACES II Foam Cushion (Goodrich)
- Cushion B: ACES II Cushion with EASE Bladders and C47 Foam (Goodrich)
- Cushion C: EPCT Foam Cushion (Oregon Aero)
- Cushion D: B-2 Operational Cushion (Oregon Aero) (Pilot)
- Cushion E: B-2 Operational Cushion (Oregon Aero) (Co-Pilot)

Instrumentation

Accelerometers and load transducers were chosen to provide the optimum resolution over the expected test load range. Full-scale data ranges were chosen to provide the expected full-scale range plus 50% to assure the capture of peak signals. All transducer bridges were balanced for optimum output prior to the start of the program. The accelerometers were adjusted in software for the effect of gravity by adding the component of a 1 G vector in line with the force of gravity that lies along the accelerometer axis.

The accelerometer and load transducer coordinate systems for the VDT carriage are shown on the sketch in Figure 4. The coordinate system is right-handed with the z-axis parallel to the vertical plane of the carriage and positive upward. The x-axis is perpendicular to the z-axis and positive eyes-forward from the manikin. The y-axis is perpendicular to the x- and z-axes according to the right-hand rule.

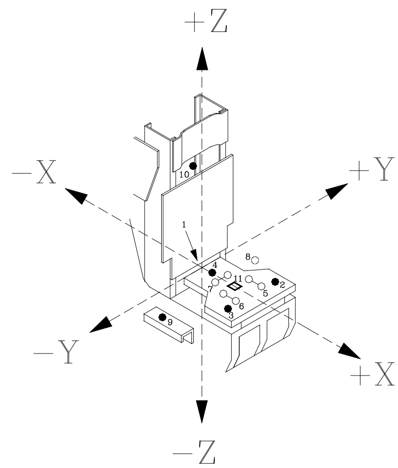


Figure 4.   VDT Sensor Coordinate System

The accelerometer and load transducer coordinate systems for the manikin are shown in Figure 5. The manikin coordinate system used was an inverted SAE J211 system. The torques were reversed from SAE J211. Flexion was measured as positive, extension negative. Compression on the neck load cell was positive, tension was negative. Shear forces in the eyes-out direction were negative.

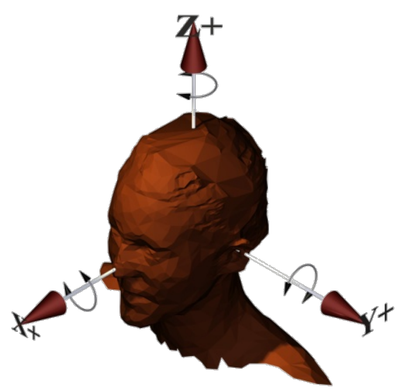


Figure 5. Manikin Coordinate System

The linear accelerometers were wired to provide a positive output voltage when the acceleration experienced by the accelerometer was applied in the +x, +y and +z directions. The load cells were wired to provide a positive output voltage when the force exerted by the load cell on the manikin was applied in the +x, +y or +z direction. The angular accelerometers were wired to provide a positive output voltage when the angular acceleration experienced by the sensor was applied in the +y direction according to the right-hand rule. The manikin load cells were wired to provide a positive output voltage when the force exerted by the load cell on the body segment was applied in the +x, +y or +z direction. The manikin torque transducers were wired to provide a positive output voltage when the torque experienced by the transducer was applied in the +x, +y or +z direction.

Instrumentation Description

Instrumentation consisted of:

- carriage acceleration (x, y, and z)
- carriage velocity (computed)
- head acceleration (x, y, and z)
- head angular acceleration (Ry)
- chest acceleration (x, y, and z)
- chest angular acceleration (Ry)
- neck loads (x, y, and z)
- neck moments (x, y, and z)
- lumbar spine loads (x, y, and z)
- lumbar spine moments (x, y, and z)
- lumbar acceleration (x, y, and z)
- lap and shoulder belt forces (x, y, and z)
- seat pan loads (x, y, and z)
- seat pan acceleration (x, y, and z)
- neck injury criteria (Nij

Transducer Calibration:

InfoSciTex coordinated all pre- and post- test calibrations on all sensors. Calibration records of individual transducers as well as the Standard Practice Instructions are maintained in the Impact Information Center. For this test program, a record was made identifying the data channel, transducer manufacturer, model number, serial number, date and sensitivity of pre-calibration, date and sensitivity of post-calibration, and percentage change. Pre and post-calibration information is maintained with the program data. The instrumentation used in this study is listed in the Program Setup and Calibration Log (Table 2).

Table 2. **Program Setup and** Calibration **Log**

DATA POINT	TRANSDUCER & MODEL	SERIAL NUMBER	PRE-CAL		DAS SENSITIVITY	BRIDGE	FULL SCALE
			DATE	SENS			
CARRIAGE X ACCEL (G)	ENDEVCO 7264-200	CC99H	12-Jul-07	3.0274 mv/g at 10V exc	.30274 mv/v/g	1/2	15 G
CARRIAGE Y ACCEL (G)	ENDEVCO 7264-200	CC86H	12-Jul-07	2.8421 mv/g at 10V exc	.28421 mv/v/g	1/2	15 G
CARRIAGE Z ACCEL (G)	ENDEVCO 2262A-200	MH82	12-Jul-07	2.0814 mv/g at 10V exc	.20814 mv/v/g	FULL	25 G
SEAT PAN X ACCEL (G)	ENTRAN EGV3-F-250	97J97J21 TP01 (X)	6-Jul-07	-1.0775 mv/g at 10V exc	-.10775 mv/v/g	FULL	15 G
SEAT PAN Y ACCEL (G)	ENTRAN EGV3-F-250	97J97J21 TP01 (Z)	6-Jul-07	-1.0478 mv/g at 10V exc	-.10478 mv/v/g	FULL	15 G
SEAT PAN Z ACCEL (G)	ENTRAN EGV3-F-250	97J97J21 TP01 (Y)	6-Jul-07	1.0407 mv/g at 10V exc	.10407 mv/v/g	FULL	25 G
LEFT LAP X FORCE (LB)	MICH-SCI 4000	2 (X)	15-Nov-06	-14.27 uv/lb at 10V exc	-.001427 mv/v/lb	FULL	1000 LB
LEFT LAP Y FORCE (LB)	MICH-SCI 4000	2 (Y)	15-Nov-06	-13.53 uv/lb at 10V exc.	-.001353 mv/v/lb	FULL	1000 LB
LEFT LAP Z FORCE (LB)	MICH-SCI 4000	2 (Z)	15-Nov-06	13.44 uv/lb at 10V exc	.001344 mv/v/lb	FULL	1000 LB

RIGHT LAP X FORCE (LB)	MICH-SCI 4000	1 (X)	15-Nov-06	-13.82 uv/lb at 10V exc	-.001382 mv/v/lb	FULL	1000 LB
RIGHT LAP Y FORCE (LB)	MICH-SCI 4000	1 (Y)	15-Nov-06	-13.69 uv/lb at 10V exc	-.001369 mv/v/lb	FULL	1000 LB
RIGHT LAP Z FORCE (LB)	MICH-SCI 4000	1 (Z)	15-Nov-06	12.99 uv/lb at 10V exc	.001299 mv/v/lb	FULL	1000 LB
LEFT SHOULDER X FORCE (LB)	MICH-SCI 4000	3 (Z)	15-Nov-06	13.35 uv/lb at 10V exc	.001335 mv/v/lb	FULL	1000 LB
LEFT SHOULDER Y FORCE (LB)	MICH-SCI 4000	3 (Y)	15-Nov-06	13.44 uv/lb at 10V exc	.001344 mv/v/lb	FULL	1000 LB
LEFT SHOULDER Z FORCE (LB)	MICH-SCI 4000	3 (X)	15-Nov-06	-14.15 uv/lb at 10V exc.	-.001415 mv/v/lb	FULL	1000 LB
RIGHT SHOULDER X FORCE (LB)	MICH-SCI 4000	4 (Z)	15-Nov-06	13.27 uv/lb at 10V exc	.001327 uv/v/lb	FULL	1000 LB
RIGHT SHOULDER Y FORCE (LB)	MICH-SCI 4000	4 (Y)	15-Nov-06	-13.82 uv/lb at 10V exc	-.001382 uv/v/lb	FULL	1000 LB
RIGHT SHOULDER Z FORCE (LB)	MICH-SCI 4000	4 (X)	15-Nov-06	-13.24 uv/lb at 10V exc	-.001324 uv/v/lb	FULL	1000 LB
LEFT SEAT PAN X FORCE (LB)	AAMRL / DYN LOADLINK	1	14-Nov-06	10.96 uv/lb at 10V exc	.001096 mv/v/lb	FULL	500 LB
RIGHT SEAT PAN X FORCE (LB)	AAMRL / DYN LOADLINK	8	14-Nov-06	-10.76 uv/lb at 10V exc	-.001076 mv/v/lb	FULL	500 LB
SEAT PAN Y FORCE (LB)	AAMRL / DYN LOADLINK	10	14-Nov-06	10.10 uv/lb at 10V exc	.001010 mv/v/lb	FULL	500 LB
LEFT SEAT PAN Z FORCE (LB)	STRANSERT FLU2.5-2SPKT	Q-3294-5	16-Nov-06	-8.05 uv/lb at 10V exc	-.000805 mv/v/lb	FULL	1500 LB
RIGHT SEAT PAN Z FORCE (LB)	STRANSERT FLU2.5-2SPKT	Q-3294-4	16-Nov-06	-8.17 uv/lb at 10V exc	-.000817 mv/v/lb	FULL	1500 LB
CENTER SEAT PAN Z FORCE (LB)	STRANSERT FLU2.5-2SPKT	Q-3294-6	16-Nov-06	-8.19 uv/lb at 10V exc	-.000819 mv/v/lb	FULL	1500 LB
INT HEAD X ACCEL (G)	ENTRAN EGV3-F-250	8XTB02 (X)	17-Jul-07	.7254 mv/g at 10V exc	.07254 mv/v/g	FULL	15 G
INT HEAD X ACCEL (G)	ENTRAN EGV3-F-250	93D93D 26TM04 (X)	6-Jun-07	1.0591 mv/g at 10V exc	.10591 mv/v/g	FULL	15 G
INT HEAD Y ACCEL (G)	ENTRAN EGV3-F-250	8XTB02 (Y)	17-Jul-07	.7395 mv/g at 10V exc	.07395 mv/v/g	FULL	15 G
INT HEAD Y ACCEL (G)	ENTRAN EGV3-F-250	93D93D 26TM04 (Y)	6-Jun-07	-1.0138 mv/g at 10V exc	-.10138 mv/v/g	FULL	15 G
INT HEAD Z ACCEL (G)	ENTRAN EGV3-F-250	8XTB02 (Z)	17-Jul-07	.7565 mv/g at 10V exc	.07565 mv/v/g	FULL	25 G
INT HEAD Z ACCEL (G)	ENTRAN EGV3-F-250	93D93D 26TM04 (Z)	6-Jun-07	1.0054 mv/g at 10V exc	.100054 mv/v/g	FULL	25 G
INT HEAD Ry ANG ACCEL (RAD/SEC2)	ENDEVCO 7303B	10229	9-Jul-07	3.52 uv/rad/sec2 at 10V exc	.000352 v/v/rad/sec2	FULL	5000 RAD/SEC2

INT HEAD Ry ANG ACCEL (RAD/SEC2)	ENDEVCO 7303B	10175	13-Mar-07	3.57 uv/rad/sec2 at 10V exc	.000357 mv/v/rad/sec2	FULL	5000 RAD/SEC2
INT NECK X FORCE (LB)	DENTON 1716A	473	18-Jun-07	-8.17 uv/lb at 10V exc	-.000817 mv/v/lb	FULL	2000 LB
INT NECK X FORCE (LB)	DENTON 1716A	625	8-Jun-07	-8.12 uv/lb at 10V exc	-.000812 mv/v/lb	FULL	2000 LB
INT NECK Y FORCE (LB)	DENTON 1716A	473	18-Jun-07	-8.12 uv/lb at 10V exc	-.000812 uv/v/lb	FULL	2000 LB
INT NECK Y FORCE (LB)	DENTON 1716A	625	8-Jun-07	-8.32 uv/lb at 10V exc	-.000832 mv/v/lb	FULL	2000 LB
INT NECK Z FORCE (LB)	DENTON 1716A	473	18-Jun-07	-4.40 uv/lb at 10V exc	-.00044 uv/v/lb	FULL	3000 LB
INT NECK Z FORCE (LB)	DENTON 1716A	625	8-Jun-07	-3.95 uv/lb at 10V exc	-.000395 mv/v/lb	FULL	3000 LB
INT NECK Mx TORQUE (IN-LB)	DENTON 1716A	473	18-Jun-07	6.67 uv/in-lb at 10V exc	.000667 mv/v/in-lb	FULL	2500 IN-LB
INT NECK Mx TORQUE (IN-LB)	DENTON 1716A	625	8-Jun-07	6.70 uv/in-lb at 10V exc	.000670 mv/v/in-lb	FULL	2500 IN-LB
INT NECK My TORQUE (IN-LB)	DENTON 1716A	473	18-Jun-07	6.63 uv/in-lb at 10V exc	.000663 mv/v/in-lb	FULL	2500 IN-LB
INT NECK My TORQUE (IN-LB)	DENTON 1716A	625	8-Jun-07	6.72 uv/in-lb at 10V exc	.000672 mv/v/in-lb	FULL	2500 IN-LB
INT NECK Mz TORQUE (IN-LB)	DENTON 1716A	473	18-Jun-07	9.07 uv/in-lb at 10V exc	.000907 mv/v/in-lb	FULL	2500 IN-LB
INT NECK Mz TORQUE (IN-LB)	DENTON 1716A	625	8-Jun-07	9.11 uv/in-lb at 10V exc	.000911 mv/v/in-lb	FULL	2500 IN-LB
INT CHEST X ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB05 (X)	17-Mar-07	1.0011 mv/g at 10V exc	.10011 mv/v/g	FULL	15 G
INT CHEST X ACCEL (G)	ENTRAN EGV3-F-250	93D93D30 TM06 (X)	17-Jul-07	1.1057 mv/g at 10V exc	.11057 mv/v/g	FULL	15 G
INT CHEST Y ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB05 (Y)	17-Mar-07	-.9686 mv/g at 10V exc	-.09686 mv/v/g	FULL	15 G
INT CHEST Y ACCEL (G)	ENTRAN EGV3-F-250	93D93D30 TM06 (Y)	17-Jul-07	1.1581 mv/g at 10V exc	.11581 mv/v/g	FULL	15 G
INT CHEST Z ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB05 (Z)	17-Mar-07	.9446 mv/g at 10V exc	.09446 mv/v/g	FULL	15 G
INT CHEST Z ACCEL (G)	ENTRAN EGV3-F-250	93D93D30 TM06 (Z)	17-Jul-07	1.2019 mv/g at 10V exc	.12019 mv/v/g	FULL	25 G
INT CHEST Ry ANG ACCEL (RAD/SEC2)	ENDEVCO 7303B	10173	9-Jul-07	3.34 mv/rad/sec2 at 10V exc	.000334 mv/v/rad/sec2	FULL	5000 RAD/SEC^2
INT CHEST Ry ANG ACCEL (RAD/SEC2)	ENDEVCO 7303B	10206	18-Jun-07	4.55 uv/rad/sec2 at 10V exc	.000455 mv/v/rad/sec2	FULL	5000 RAD/SEC^2
INT LUMBAR X ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB03 (X)	13-Mar-07	.8837 mv/g at 10V exc	.08837 mv/v/g	FULL	15 G
INT LUMBAR X ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB02 (X)	13-Mar-07	.9856 mv/g at 10V exc	.09856 mv/v/g	FULL	15 G

INT LUMBAR Y ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB03 (Y)	13-Mar-07	-.8456 mv/g at 10V exc	-.08456 mv/v/g	FULL	15 G
INT LUMBAR Y ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB02 (Y)	13-Mar-07	.9672 mv/g at 10V exc	.09672 mv/v/g	FULL	15 G
INT LUMBAR Z ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB03 (Z)	13-Mar-07	.8654 mv/g at 10V exc	.08654 mv/v/g	FULL	25 G
INT LUMBAR Z ACCEL (G)	ENTRAN EGV3-F-250	97C97C28 TB02 (Z)	13-Mar-07	.9530 mv/g at 10V exc	.09530 mv/v/g	FULL	25 G
INT LUMBAR X FORCE (LB)	DENTON 1914A	310	13-Jun-07	-6.66 uv/lb at 10V exc	-.000666 mv/v/lb	FULL	3000 LB
INT LUMBAR X FORCE (LB)	DENTON 1914A	438	8-Mar-07	6.64 uv/lb at 10V exc	.000664 mv/v/lb	FULL	3000 LB
INT LUMBAR Y FORCE (LB)	DENTON 1914A	310	13-Jun-07	-6.67 uv/lb at 10V exc	-.000667 mv/v/lb	FULL	3000 LB
INT LUMBAR Y FORCE (LB)	DENTON 1914A	438	8-Mar-07	6.67 uv/lb at 10v exc	.000667 mv/v/lb	FULL	3000 LB
INT LUMBAR Z FORCE (LB)	DENTON 1914A	310	13-Jun-07	-2.41 uv/lb at 10V exc	-.000241 mv/v/lb	FULL	5000 LB
INT LUMBAR Z FORCE (LB)	DENTON 1914A	438	8-Mar-07	2.80 uv/lb at 10V exc	.000280 mv/v/lb	FULL	5000 LB
INT LUMBAR Mx TORQUE (IN-LB)	DENTON 1914A	310	13-Jun-07	5.12 uv/in-lb at 10V exc	.000512 mv/v/in-lb	FULL	3000 IN-LB
INT LUMBAR Mx TORQUE (IN-LB)	DENTON 1914A	438	8-Mar-07	5.24 uv/in-lb at 10V exc	.000524 mv/v/in-lb	FULL	3000 IN-LB
INT LUMBAR My TORQUE (IN-LB)	DENTON 1914A	310	13-Jun-07	5.13 uv/in-lb at 10V exc	.000513 mv/v/in-lb	FULL	3000 IN-LB
INT LUMBAR My TORQUE (IN-LB)	DENTON 1914A	438	8-Mar-07	5.15 uvin-lb at 10V exc	.000515 mv/v/in-lb	FULL	3000 IN-LB
INT LUMBAR Mz TORQUE (IN-LB)	DENTON 1914A	310	13-Jun-07	8.75 uv/in-lb at 10V exc	.000875 mv/v/in-lb	FULL	3000 IN-LB
INT LUMBAR Mz TORQUE (IN-LB)	DENTON 1914A	438	8-Mar-07	8.79 uv/in-lb at 10V exc	.000879 mv/v/in-lb	FULL	3000 IN-LB

Data Acquisition

The Master Instrumentation Control Unit in the Instrumentation Station controlled data acquisition. Using a comparator, a test was initiated when the countdown clock reached zero. The comparator was set to start data collection at a pre-selected time. All data were collected at 1,000 samples per second and filtered at a 120 Hz cutoff frequency using an 8-pole Butterworth filter.

Data were recorded to establish a zero reference for all transducers following the attachment of the manikin and riser straps to the VDT test fixture. The manikin was lifted up by the harness using a hoist to remove the load from the riser load cells, prior to collecting the zero reference data. The reference data were stored separately from the test data and were used in the processing of the test data. A reference mark pulse was generated to mark the electronic data at a pre-selected time after test initiation to place the reference mark close to the impact point. The reference mark time was used as the start time for data processing of the electronic data.

TDAS PRO Data Acquisition System:

The TDAS PRO Data Acquisition System (DAS), manufactured by Diversified Technical Systems (DTS), Inc., was used for this test program. The TDAS PRO is a ruggedized, DC powered, fully programmable signal conditioning and recording system for transducers and events. The TDAS PRO was designed to withstand a 100 G shock. The main unit was installed at the top of the VDT carriage as shown in Figure 6.

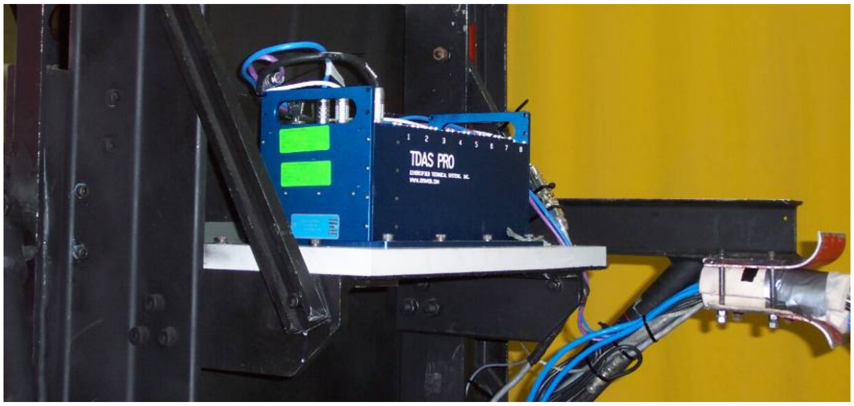


Figure 6. TDAS PRO

The TDAS PRO can accommodate up to 64 channels. The signal conditioning accepts a variety of transducers including full and partial bridges, voltage, and piezoresistive. Transducer signals are amplified, filtered, digitized and recorded in onboard solid-state memory. The data acquisition system is controlled through an Ethernet interface using the Ethernet instruction language. A desktop PC with an Ethernet board configures the TDAS PRO before testing and retrieves the data after each test.

Video:

Two carriage-mounted Weinberger SpeedCam Visario cameras (Figure 7) were used to collect video and target motion data. One camera was mounted directly to the side of the carriage, while the other was mounted at an oblique angle to the carriage. The SpeedCam system is capable of data acquisition at up to 10,000 frames per second (fps). The Control Unit allows for simultaneous operation of multiple cameras and controls the entire data management from system control, post-processing and visualization to archiving of the completed image sequences.

The interface between cameras and the Control Unit occurs via LocalLinks. LocalLinks are system-specific cables, 5 and 15 meters in length, which carry all video and control data as well as the power for the connected camera heads.

The images for this study were collected at 500 fps. The video files were downloaded and converted to AVI format and stored in the RHPA Biodynamic Data Bank.

The interface between cameras and the Control Unit occurs via LocalLinks. LocalLinks are system-specific cables, 5 and 15 meters in length, which carry all video and control data as well

as the power for the connected camera heads. The images for this study were collected at 500 fps. The video files were downloaded and converted to AVI format (Appendix A).

Figure 7. Weinberger SpeedCam Visario camera

Evaluation Criteria

Analysis of head, chest, and lumbar accelerations, neck and lumbar loads, and injury risk assessment were conducted at the conclusion of the test program. The dynamic response index (DRI) was calculated for the seat pan accelerations only. The DRI for the seat pan acceleration estimates what the dynamic response would have been if the seat cushion had not been present.

The Dynamic Response Index (DRI) model was developed to estimate the probability of compression-type fractures in the lower spine due to the acceleration along the longitudinal axis of the spine. The model was verified using operational injury rates from escape systems. The DRI model was incorporated into the United States Air Force and multinational specifications for ejection seats and escape capsules. The DRI is a single-degree-of-freedom lumped parameter model. The DRI corresponds to the DRZ component of the MDRC multi-axis model. The DRI limit for a 5% risk of major injury is 18.

The DRI is computed using the following equations:

$$\ddot{\delta} + 2\zeta\omega_n\dot{\delta} + \omega_n^2\delta = a \qquad \mathrm{DRI} = \frac{\omega_n^2\delta}{g}$$

Where:
$\ddot{\delta}$ is the relative acceleration between the seat and the dynamic response model mass.
$\dot{\delta}$ is the relative velocity between the seat and the model mass.
δ is the compression/tension of the model spring. A positive value represents compression.
ζ is the damping coefficient ratio (0.224).
ω_n is the natural frequency of the model (52.9 rad/sec).
a is the acceleration component that lies along the longitudinal axis of the spine as measured by the seat pan accelerometer.

g is the acceleration of gravity.

The resultant lumbar load limits are as follows:
5th Percentile (LOIS): Less than 1,000 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

50th Percentile: Less than 1,500 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

95th Percentile: Less than 2,200 pounds transferred to the lumbar area when exposed to vertical impact tests of 12 nominal Gz at 28-31 Feet per Second maximum velocity, Pulse Duration 140-150 Milliseconds and Rise Time between 65-70 Milliseconds.

Rationale for the maximum lumbar load limits
The dynamic test lumbar spinal load of 2206 pounds for the large manikin was calculated based on the Federal Aviation Administration's maximum load of 1500 pounds for a 170 pound occupant. The number was scaled up to be commensurate with the seat cushion assembly specification requirement for a 250 pound occupant using the following formula:

$$\frac{1500 \text{ lb X } 250 \text{ lb}}{170 \text{ lb}} = 2206 \text{ lb}$$

Likewise, the number was scaled down to be commensurate with the seat cushion assembly specification requirement for the small occupant.

Neck Injury Criteria (Nij)
The combined-cervical-force-and-moment limit, expressed as Neck Injury Criteria (Nij), was calculated for this program even though nothing was added to the standard HGU-55/P helmet (NO NVGs, nor HMDs). The peak Nij aerospace specified limit of 0.5 was used for all tests. The Nij value can be calculated throughout the time history of the impact test according to the following formula:

$$Nij = F/F_{int} + M/M_{int}$$

where:
F is the measured axial neck tension/compression or shear in pounds
F_{int} is the critical intercept load
M is the measured flexion/extension bending moment in in-lbs
M_{int} is the critical intercept moment

The Nij criteria do not apply to loading in pure tension or compression. Nij values are computed for each of the following combined loading cases:

N_{te} = Tension - Extension
N_{tf} = Tension - Flexion

N_{ce} = Compression - Extension
N_{cf} = Compression - Flexion

The critical intercept values for Nij calculation at C0-C1 for this program would be based on the three sized Hybrid III manikins used in this study (Table 3).

Table 3. Critical Intercept Values for Nij Calculation at C0-C1 for a Given Occupant Size

	Small Female Hybrid III Type Manikin	Mid-Sized Male Hybrid III Type Manikin	Large Male Hybrid III Type Manikin
Tension (lbs) (+F_z)	964	1530	1847
Compression (lbs) (-F_z)	872	1385	1673
Flexion (in-lbs) (+My)	1372	2744	3673
Extension (in-lbs) (-My)	593	1195	1584

Photographic Data

Digital still photos were taken prior to each test (Appendix B).

Results

VDT tests: Selected results of the VDT tests are shown in Table 4. Data plots and summary sheets for each channel of collected data are found in Appendix C.

Table 4. Vertical Impact Test Data

Test	Manikin	Cell	Cushion	Carriage Z (g)	Pan DRI	Pan Resultant Minus Tare (lb.)	Lumbar Resultant (g)	Lumbar Resultant (lb.)	Peak Nce Level	Peak Ncf Level	Prob. Of AIS ≥ 3 Nce Injury	Prob. Of AIS ≥ 3 Ncf Injury
5748	LOIS	I	A	11.95	15.75	1982.16	16.48	803.11	0.06	0.22	0.04	0.06
5749	LOIS	I	A	12.08	15.81	1999.91	16.01	838.91	0.06	0.21	0.04	0.06
5750	LOIS	K	C	11.86	15.80	2109.01	16.84	896.86	0.06	0.25	0.04	0.06
5751	LOIS	K	C	11.98	15.89	2104.43	17.35	878.66	0.05	0.24	0.04	0.06
5752	LOIS	J	B	12.00	15.78	2298.62	18.64	993.00	0.06	0.27	0.04	0.06
5753	LOIS	J	B	12.12	15.69	2122.64	17.07	884.93	0.06	0.24	0.04	0.06
5754	LOIS	J	B	11.89	15.62	2138.38	17.47	958.27	0.05	0.25	0.04	0.06
5755	LOIS	J	B	11.94	15.63	2195.19	17.21	947.44	0.05	0.25	0.04	0.06
5756	HB3-50	E	A	11.99	16.09	3069.04	16.41	N/A	0.05	0.14	0.04	0.05
5757	LARD	A	A	11.94	15.93	4640.85	16.26	1488.07	0.22	0.13	0.06	0.05
5758	LARD	A	A	11.94	15.82	4617.05	16.36	1418.41	0.20	0.14	0.06	0.05
5759	LARD	C	C	11.78	15.81	4614.44	15.93	1430.99	0.19	0.14	0.05	0.05
5760	LARD	C	C	11.94	15.96	4709.94	15.59	1393.65	0.15	0.14	0.05	0.05
5761	LARD	A	A	11.92	16.01	4722.13	16.74	1439.96	0.17	0.16	0.05	0.05
5762	LARD	B	B	11.99	15.93	4698.91	16.41	1410.38	0.13	0.15	0.05	0.05
5763	LARD	B	B	11.98	15.88	4917.23	16.39	1463.28	0.18	0.14	0.05	0.05
5764	LARD	B	B	12.02	15.93	4730.74	16.09	1368.74	0.15	0.15	0.05	0.05
5765	LARD	B	B	12.04	15.82	4681.09	16.61	1464.70	0.17	0.14	0.05	0.05
5766	LARD	B	B	11.95	15.93	4677.38	16.39	1327.89	0.13	0.15	0.05	0.05
5767	HB3-50	E	A	11.97	16.08	3092.95	15.28	N/A	0.06	0.14	0.04	0.05
5768	HB3-50	E	A	11.90	16.06	3228.17	16.76	1199.61	0.06	0.15	0.04	0.05

5769	HB3-50	E	A	12.01	16.12	3124.47	16.19	1175.84	0.05	0.16	0.04	0.05
5770	HB3-50	H	D	11.83	16.03	3411.15	16.97	1261.70	0.06	0.16	0.04	0.05
5771	HB3-50	H	D	11.86	16.01	3345.62	17.10	1204.21	0.06	0.15	0.04	0.05
5772	HB3-50	H	D	11.98	16.09	3313.70	16.36	1133.05	0.06	0.14	0.04	0.05
5773	HB3-50	H	D	11.91	16.06	3296.28	16.34	1129.49	0.06	0.14	0.04	0.05
5774	HB3-50	F	B	11.95	15.92	3096.32	16.68	1098.97	0.06	0.14	0.04	0.05
5775	HB3-50	F	B	11.97	15.92	3171.66	16.98	1134.62	0.05	0.14	0.04	0.05
5776	HB3-50	F	B	12.10	15.93	3048.61	16.72	1073.11	0.06	0.14	0.04	0.05
5777	HB3-50	F	B	11.95	16.05	3233.33	17.43	1141.23	0.04	0.15	0.04	0.05
5778	HB3-50	G	C	12.02	16.04	3287.15	16.29	1157.28	0.04	0.15	0.04	0.05
5779	HB3-50	G	C	12.04	16.05	3191.30	16.10	1126.90	0.04	0.14	0.04	0.05
	Mean			11.96	15.92	3402.18	16.61	1174.78	0.09	0.17	0.05	0.05
	Std Dev			0.07	0.14	998.04	0.63	210.99	0.05	0.04	0.00	0.00
	Lower Limit			11.76	15.54	636.14	14.87	595.87	-0.06	0.05	0.03	0.04
	Upper Limit			12.17	16.30	6168.22	18.35	1753.68	0.24	0.29	0.06	0.06

A total of 32 tests were conducted and analyzed for this program focusing on the critical issues outlined above. The tests were conducted at 12 G on the Air Force Research Laboratory's (AFRL) Vertical Deceleration Tower (VDT) at Wright-Patterson Air Force Base, OH, using a small (LOIS), mid-sized (modified 50th percentile aerospace Hybrid III) and large manikin (LARD).

In order to quantify the phase I production and the B-2 operational seat pan cushions' responses to the acceleration levels, and investigate the occupant risk implications associated with these cushions, one should consider the resultant lumbar loads (lbf).

Generally, the phase I production and B-2 operational supplied cushions resulted in similar resultant lumbar loads for the all manikins tested as compared to those of the baseline factory-installed F-16 ACES II cushions.

None of the lumbar loads exceeded the recommended maximum lumbar load limits. None of the seat pan DRI's exceeded the limit of 18.

All probability of injury calculations for the Abbreviated Injury Scale (AIS $\geq$ 3) were based on the formulas found in the National Highway Traffic Safety Administration's November 1999 report.[11] For this program, all Ncf and Nce values computed for the LARD manikin correspond to a 5.0 - 6.0% probability of an AIS $\geq$ 3 injury. All Ncf and Nce values computed for the 50th percentile manikin correspond to a 4.0 - 5.0% probability of an AIS $\geq$ 3 injury. All Ncf and Nce values computed for the LOIS manikin correspond to a 4.0 – 6.0% probability of an AIS $\geq$ 3 injury.

References

1. Staff report. Report: B-2 caught fire before crashing. Tuesday Feb 26, 2008. From Air Force Times Website: http://www.airforcetimes.com/news/2008/02/airforce_B2_crash_022608w/

2. Perry, C.E., Nguyen, T.Q, Pint, S.M., Evaluation of Proposed Seat Cushions to Vertical Impact, SAFE Symposium Proceedings, 2000.

3. Stech, E.L. and Payne, P.R., Dynamic models of the human body, Aerospace Medical Research Laboratory Report, AMRL-TR-66-157, Wright-Patterson Air Force Base, Ohio, 1969.

4. Performance Specification, Seat System, Upward Ejection, Aircraft, General Specification for, MIL-PRF-9479D (USAF), Dec., 1996.

5. Brinkley, J.W. and Raddin Jr., J.R., Biodynamics: transitory acceleration. In R.L. DeHart (Ed.), Fundamentals of aerospace medicine. Philadelphia: Lea and Febiger, 1985.

6. Hawkins, F.H., Crew seats in transport aircraft. KLM Technical Research Bureau, Oct 27, 1994.

7. Hearon, B.F. and Brinkley, J.W., Effect of seat cushions on human response to +Gz impact. Aviation, Space, and Environmental Medicine, 57: 113-121, 1986.

8. Dennis, M.R. and Mandel, P.H., Improved comfort, safety, and communications for aviators. Re-thinking the man-machine interface. Oregon Aero, Inc., Dec 5, 1992.

9. Brinkley, J.W., Perry, C.E., Orzech, M.A., and Salerno, M.D., Evaluation of a proposed F-4 ejection seat cushion by +Gz impact tests (Technical Report AL/CF-TR-1993-0160). Wright-Patterson AFB OH: Armstrong Laboratory, 1993.

10. Perry, C.E. Impact Evaluation of a Proposed B-2 Seat Cushion. SAFE Journal, 27(1): 24-31, 1997.

11. Eppinger, R., Sun, E., Bandak, F., Haffner, M., Khaewpong, N., Maltese, M., Shashi, K., Nguyen, T., Takhounts, E., Tannous, R., Zhang, A., Saul, R., “Supplement: Development of Improved Injury Criteria for the Assessment of Advanced Automotive Restraint Systems – II,” National Highway Traffic Safety Administration, November 1999.

APPENDIX E: Environmental Results

DAYTON T. BROWN INC.

Founded 1950

ENGINEERING AND TEST DIVISION
CHURCH STREET, BOHEMIA, LONG ISLAND, NEW YORK 11716 (631) 589-6300

TEST REPORT NO.: DTB04R09-0623

DAYTON T. BROWN, INC. JOB NO.: 410742-00-000

CUSTOMER: UNITED STATES AIR FORCE
2800 Q STREET, BLDG. 824
WRIGHT-PATTERSON AFB, OH 45433

SUBJECT: ENVIRONMENTAL TEST PROGRAM CONDUCTED ON VARIOUS SEAT CUSHIONS AND ONE RESTRAINT SYSTEM

PURCHASE ORDER NO.: 10866

ATTENTION: MR. SCOTT FLEMING

THIS REPORT CONTAINS: THREE PAGES AND NINE ENCLOSURES

TEST ENGINEER	John Long J. LONG
DEPARTMENT SUPERVISOR	G Hyland G. HYLAND
QUALITY DEPARTMENT	L. Privett
DATE	7 MAY 2009

THE DATA CONTAINED IN THIS REPORT WAS OBTAINED BY TESTING IN COMPLIANCE WITH THE APPLICABLE TEST SPECIFICATION AS NOTED

TABLE OF CONTENTS

1.0 ABSTRACT

This test report details the results of the environmental test program conducted on Various Seat Cushions and one Restraint System under reference (a) to the requirements of references (c) through (f).

Results of the tests are detailed in the following text.

The test items were operated during specified portions of testing.

Test data pertinent to this program will remain on file at Dayton T. Brown, Inc. for 90 days.

The test results recorded in this report relate only to those items tested.

2.0 REFERENCES

(a)	Customer Purchase Order No.:	10866
(b)	Dayton T. Brown, Inc. Job No.:	410742-00-000
(c)	Test Specification:	Department of Defense System Requirements Document No. AFRL/HEPA, dated September 2006
(d)	Test Specification:	MIL-STD-810F
(e)	Dayton T. Brown, Inc. Quotation:	Dayton T. Brown, Inc. Quotation No. GSL-08-0708C, dated 8 December 2008
(f)	E-mail:	E-mail from S. Fleming (USAF) to J. Long (Dayton T. Brown, Inc.), dated 2 February 2009

3.0 ADMINISTRATIVE INFORMATION

Customer	United States Air Force 2800 Q Street, Bldg. 824 Wright-Patterson AFB, OH 45433
Test Item Description	Various Seat Cushions and one Restraint System
Serial Nos.	Various
Quantity Received	Various
Date Received	26 January 2009
Dates Tested	26 January through 20 March 2009
Date Shipped	20 March 2009
Customer Representative Present During Testing	
Scott Fleming	United States Air Force

4.0 TEST PROGRAM OUTLINE

Test	Test Item Description	Results
High Temperature Storage and Operation	Seat Cushions and Restraint System	See Enclosure 1 for detailed results.
Humidity	Seat Cushions	See Enclosure 2 for detailed results.
Low Temperature Storage and Operation	Seat Cushions and Restraint System	See Enclosure 3 for detailed results.
Altitude	Seat Cushions	See Enclosure 4 for detailed results.
Blowing Dust	Seat Cushions	See Enclosure 5 for detailed results.
Salt Fog	Seat Cushions and Restraint System	See Enclosure 6 for detailed results.
Blowing Sand	Seat Cushions	See Enclosure 7 for detailed results.
Fungus	Seat Cushions	See Enclosure 8 for detailed results.
Explosive Decompression	Seat Cushions	See Enclosure 9 for detailed results.

Enclosure 1

High Temperature Storage and Operation Test and Results

09-0623

TEST REQUIREMENT

The high temperature storage and operation test shall be conducted in accordance with references (c) through (f).

TEST RESULTS

The high temperature storage and operation test was conducted on the following test items:

1. Oregon Aero Seat Cushion, Serial No. 103926
2. Baseline Seat Cushion, Serial No. 2A
3. Goodrich (Air Bladder) Seat Cushion, Serial No. 7
4. Oregon Aero Seat Back, Serial No. 103966
5. Restraint System

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

The test items were nonoperating during the high temperature storage test.

Refer to the test data sheets on pages 3 through 9 of this enclosure for the results of the high temperature storage test.

An operational check of the Goodrich (Air Bladder) Seat Cushion and the Restraint System after the completion of the high temperature storage test revealed that both test items appeared to be functioning correctly after this test. Specifically, the Goodrich (Air Bladder) Seat Cushion pump continued to cycle on and off as required. Additionally, the belt of the Restraint System was pulled completely out and subsequently released which resulted in the automatic retraction of the belt.

The Goodrich (Air Bladder) Seat Cushion was operated during the high temperature operation test.

Refer to the test data sheets on pages 10 through 12 of this enclosure for the results of the high temperature operation test.

The test items completed all phases of testing. However, the Goodrich (Air Bladder) Seat Cushion was found to be malfunctioning (i.e. flashing red and green lights and the pump not operating) during the high temperature operation test several times. Each time this condition was discovered, the switch on the test item was cycled off then on and the test item subsequently appeared to be operating correctly again.

A post-test visual inspection of the test items revealed no anomalies due to testing.

A post-test operational check of the Goodrich (Air Bladder) Seat Cushion and the Restraint System was conducted. The belt of the Restraint System was pulled completely out and subsequently released which resulted in the automatic retraction of the belt. However, the Goodrich (Air Bladder) Seat Cushion would not operate correctly. Each attempt to turn the test item on resulted in the red and green lights flashing and the pump not operating.

1/28-

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 1 of 10

Job No: 410742-00-000 Test: High Temperature Storage Date: 28 Jan 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1130	0	95	95.0	23.7		JP
1230	1	95	94.8	14.5		JP
1330	2	94	94.1	12.7		JP
1430	3	94	93.4	11.4		JP
1530	4	92	92.1	11.0		JP
1630	5	92	91.7	10.9		JP
1730	6	91	92.0	10.5		VD
1830	7	97	96.8	10.1		VD
1930	8	104	104.0	10.0		VD
2030	9	111	110.7	10.2		VD
2130	10	124	124.5	12.3		VD
2230	11	133	133.3	12.0		VD
2330	12	145	145.6	10.7		VD
0030	13	156	155.7	7.2		VD
0130	14	158	157.6	5.9		[illegible]
0230	15	160	159.6	4.7		[illegible]
0330	16	158	158.0	4.1		[illegible]
0430	17	153	153.0	4.1		[illegible]
0530	18	145	145.2	4.1		[illegible]
0630	19	131	129.6	2.9		JP
0730	20	118	117.6	3.2		JP
0830	21	105	105.2	3.9		[illegible]
0930	22	103	103.3	4.5		[illegible]
1030	23	99	99.8	5.1		[illegible]
1130	24	95	95.0	5.8		[illegible]
					Cycle 1 of 7	

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: High Temperature Storage Date: 29 Jan 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1130	0	95	95.0	5.8		
1230	1	95	95.0	6.0		
1330	2	94	94.3	6.2		
1430	3	94	94.1	6.5		
1530	4	92	92.1	7.2		HE
1630	5	92	91.8	7.2		HE
1730	6	91	91.0	7.3		HE
1830	7	97	97.0	6.8		HE
1930	8	104	103.8	6.2		HE
2030	9	111	110.8	5.6		HE
2130	10	124	123.9	14.8		HE
2230	11	133	133.1	18.8		HE
2330	12	145	145.3	14.6		HE
0030	13	156	155.8	7.3		
0130	14	158	158.0	4.9		
0230	15	160	160.1	3.6		
0330	16	158	156.7	3.1		
0430	17	153	153.0	2.2		
0530	18	145	144.5	1.9		
0630	19	131	131.2	1.9		
0730	20	118	117.6	2.6		
0830	21	105	105.2	3.4		mm
0930 ~~1030~~	22	103	103.1	4.9		mm
1030	23	99	99.2	5.5		mm
1130	24	95	95.2	6.3		mm
					Cycle 2 of 7	

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: High Temperature Storage Date: 30 JAN 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1130	0	95	98.2	5.5		mm
1230	1	95	95.5	6.1		mm
1330	2	94	94.2	6.2		mm
1430	3	94	94.0	6.2		mm
1530	4	92	92.1	6.9		mm
1630	5	92	91.2	7.1		VD
1730	6	91	91.2	7.1		VD
1830	7	97	97.0	7.1		VD
1930	8	104	103.6	8.3		VD
2030	9	111	110.7	6.2		VD
2130	10	124	123.5	16.8		VD
2230	11	133	133.9	19.8		VD
2330	12	145	145.4	14.3		VD
0030	13	156	155.5	6.7		VD
0130	14	158	158.1	4.5		VD
0230	15	160	159.1	3.8		VD
0330	16	158	157.5	2.6		VD
0430	17	153	153.2	2.1		VD
0530	18	145	145.2	1.6		VD
0630	19	131	131.2	1.5		JP
0730	20	118	118.9	2.0		JP
0830	21	105	105.1	2.6		JP
0930	22	103	102.9	3.0		JP
1030	23	99	99.7	3.5		JP
1130	24	95	95.4	4.0		JP
					Cycle 3 of 7	

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: High Temperature Storage Date: 31 Jan 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1130	0	95	95.4	4.0		pw
1230	1	95	95.2	4.1		pw
1330	2	94	94.2	4.5		pw
1430	3	94	94.1	4.7		pw
1530	4	92	91.9	4.8		pw
1630	5	92	91.6	5.0		pw
1730	6	91	91.0	5.1		mm
1830	7	97	97.5	5.1		mm
1930	8	104	104.0	4.9		mm
2030	9	111	111.8	4.8		mm
2130	10	124	123.4	8.9		mm
2230	11	133	132.1	14.8		mm
2330	12	145	144.2	13.6		mm
0030	13	156	156.2	5.2		[illegible]
0130	14	158	158.4	3.8		[illegible]
0230	15	160	159.8	2.8		[illegible]
0330	16	158	157.8	2.3		[illegible]
0430	17	153	152.1	2.3		h
0530	18	145	144.2	1.8		h
0630	19	131	129.7	1.5		h
0730	20	118	117.1	2.1		h
0830	21	105	104.8	3.1		JP
0930	22	103	102.0	3.5		JP
1030	23	99	98.2	4.1		JP
1130	24	95	94.3	9.7		JP
					Cycle 4 of 7	

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.

Founded 1950

Page 5 of 10

Job No: 410742-00-000 Test: High Temperature Storage Date: 1 Feb 19

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1130	0	95	94.3	4.7		JP
1230	1	95	94.3	4.9		JP
1330	2	94	93.8	5.4		JP
1430	3	94	94.1	5.5		JP
1530	4	92	91.8	5.9		JP
1630	5	92	91.7	5.8		EW
1730	6	91	91.2	6.5		EW
1830	7	97	97.5	6.2		EW
1930	8	104	104.3	7.4		EW
2030	9	111	110.1	6.2		EW
2130	10	124	124.2	10.4		EW
2230	11	133	133.4	14.2		EW
2330	12	145	144.8	11.2		EW
0030	13	156	156.0	6.1		n
0130	14	158	158.1	3.5		n
0230	15	160	159.3	2.8		n
0330	16	158	157.8	2.5		n
0430	17	153	152.3	2.6		n
0530	18	145	145.0	2.6		n
0630	19	131	131.6	2.0		n
0730	20	118	117.6	2.5		n
0830	21	105	104.5	3.5		[illegible]
0930	22	103	102.5	4.1		[illegible]
1030	23	99	99.1	4.5		[illegible]
1130	24	95	95.2	5.4		[illegible]
					Cycle 5 of 7	

[signature]

09-0623 Enc 1 Pg 7

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: High Temperature Storage Date: 2 FEB 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1130	0	95	95.2	5.4		[illegible]
1230	1	95	94.9	6.5		[illegible]
1330	2	94	93.9	6.8		[illegible]
1430	3	94	94.0	7.0		[illegible]
1530	4	92	91.6	7.8		[illegible]
1630	5	92	91.8	7.8		VD
1730	6	91	91.0	8.1		VD
1830	7	97	97.4	8.2		VD
1930	8	104	104.2	15.5		VD
2030	9	111	110.8	15.3		VD
2130	10	124	124.7	19.7		VD
2230	11	133	133.5	17.1		VD
2330	12	145	145.9	11.5		VD
0030	13	156	156.1	4.9		[illegible]
0130	14	158	158.2	3.7		[illegible]
0230	15	160	159.6	3.0		[illegible]
0330	16	158	156.9	2.7		[illegible]
0430	17	153	152.8	2.7		[illegible]
0530	18	145	144.7	3.0		[illegible]
0630	19	131	131.0	2.5		[illegible]
0730	20	118	117.3	2.7		[illegible]
0830	21	105	104.7	3.8		[illegible]
0930	22	103	102.7	5.5		[illegible]
1030	23	99	98.7	6.2		[illegible]
1130	24	95	95.2	6.7		[illegible]
					Cycle 6 of 7	

John [illegible]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 7 of 10

Job No: 410742-00-000 Test: High Temperature Storage Date: 3FEB09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	Unit Temp	REMARKS	TECH
1130	0	95	95.2	6.7			mm
1230	1	95	94.6	7.2			mm
1330	2	94	93.9	7.7			mm
1430	3	94	93.9	7.4			mm
1530	4	92	91.8	7.4			mm
1630	5	92	92.1	7.4			VD
1730	6	91	90.3	7.3			VD
1830	7	97	97.0	6.8			VD
1930	8	104	104.1	6.7			VD
2030	9	111	110.7	6.4			VD
2130	10	124	123.3	15.0			VD
2230	11	133	133.3	17.0			VD
2330	12	145	145.6	12.8			VD
0030	13	156	156.1	6.1			[illegible]
0130	14	158	158.2	4.3			[illegible]
0230	15	160	159.4	3.3			[illegible]
0330	16	158	157.8	2.7			[illegible]
0430	17	153	152.5	2.5			[illegible]
0530	18	145	144.7	2.1			[illegible]
0630	19	131	131.2	1.5			[illegible]
0730	20	118	117.5	1.9			[illegible]
0830	21	105	104.8	2.9			mm
0930	22	103	102.5	3.4			mm
1030	23	99	99.0	3.9			mm
1130	24	95	94.7	4.6		H/T Storage Complete	JB
						Cycle 7 of 7	

John [illegible]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 8 of 10

Job No: 410742-00-000 Test: High Temperature OPERATION Date: 4FEB09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1245	0	95	94.6	4.5		[illegible]
1345	1	95	95.0	4.5		[illegible]
1445	2	94	93.7	4.9		[illegible]
1545	3	94	93.6	4.9		[illegible]
1645	4	92	92.1	5.2		VD
1745	5	92	91.6	5.4		VD
1845	6	91	91.0	5.6		VD
1945	7	97	97.6	5.4		VD
2045	8	104	104.2	4.5		VD
2145	9	111	110.7	5.0		VD
2245	10	124	123.2	11.7		VD
2345	11	133	133.4	16.0		VD
0045	12	145	145.6	9.4		RB
0145	13	156	155.6	7.2		RB
0245	14	158	158.0	3.4		RB
0345	15	160	159.3	2.6		RB
0445	16	158	158.2	1.9		RB
0545	17	153	154.0	1.8		RB
0645	18	145	147.0	1.0		RB
0745	19	131	133.0	0.8		RB
0845	20	118	118.0	1.5		[illegible]
0945	21	105	104.9	2.1		[illegible]
1045	22	103	103.2	2.9	(1) Unit Ops Chk conducted @1050	[illegible]
1145	23	99	99.3	3.2		[illegible]
1245	24	95	95.9	3.7		[illegible]
					Cycle 1 of 3	

(1) Red and Green lights flashing. Unit does not appear to be operating. Reset Switch (OFF then ON) and unit appears to be operating correctly again. [illegible]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC. Founded 1950

Page 9 of 10

Job No: 410742-00-000 Test: High Temperature OPERATION Date: 5 FEB 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1245	0	95	95.9	3.7		
1345	1	95	95.0	4.2	OPS CHK - Green and Red lights flashing - Reset	
1445	2	94	94.3	4.1		
1545	3	94	94.3	4.4		
1645	4	92	91.9	4.6		
1745	5	92	91.8	5.1		
1845	6	91	91.5	4.8		
1945	7	97	97.3	4.8		
2045	8	104	103.4	4.7		
2145	9	111	110.8	5.1		
2245	10	124	124.0	12.2		
2345	11	133	133.2	15.2		
0045	12	145	145.2	7.8		
0145	13	156	154.6	4.6		
0245	14	158	158.7	2.9		
0345	15	160	159.4	1.9		
0445	16	158	157.8	1.7		
0545	17	153	153.1	1.6		
0645	18	145	148	1.5	*	
0745	19	131	134	1.3	*	
0845	20	118	121	1.8	* OPS CHK - Red and Green lights flashing - Reset	
0945	21	105	104.9	2.2		
1045	22	103	102.9	2.6		
1145	23	99	99.0	3.4		
1245	24	95	95.2	3.8		
					Cycle 2 of 3	

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 10 of 10

Job No: 410742-00-000 Test: High Temperature Date: 6 Feb 09

TIME	TEST TIME HOURS	Req Cham Temp	Actual Cham Temp	Actual %RH	REMARKS	TECH
1245	0	95	95.2	3.8		MJ
1345	1	95	93.9	5.1	Ops Check OK Battery Changed – Unit (1) jb	JB
1445	2	94	94.1	4.8		MJ
1545	3	94	93.9	4.7		MP
1645	4	92	92.6	5.0		VD
1745	5	92	92.3	5.2		VD
1845	6	91	91.2	5.3		VD
1945	7	97	97.1	5.0		VD
2045	8	104	103.8	4.8		VD
2145	9	111	111.3	10.0		VD
2245	10	124	123.8	13.1		VD
2345	11	133	133.2	14.7		VD
0045	12	145	145.1	5.5		MJ
0145	13	156	155.7	3.5		MK
0245	14	158	158.2	2.4		MK
0345	15	160	159.6	1.7		MP
0445	16	158	158.2	1.5		MP
0545	17	153	153.1	1.3		MP
0645	18	145	145.0	1.5		MP
0745	19	131	131.6	1.0		MP
0845	20	118	118.2	1.6	Ops check Red-Green flashing (2)	SM
0945	21	105	104.5	2.56		SM
1045	22	103	102.7	3.1		SM
1145	23	99	98.8	3.7		SM
1245	24	95	94.6	4.4		SM
					Cycle 3 of 3	MP

(1) Unit Flashing Green-Red lights after battery changed Reset does not seem to change this. jb

(2) Red → Green Light flashing

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: 410742-00 **TEST: HIGH TEMPERATURE STORAGE AND OPERATION**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, TEMPERATURE/HUMIDITY	RUSSELL	RD-64-705-705	04E-007	N/A	N.C.R.
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-13	RTD ± 0.5°F, RH ± 0.2% RH	08/16/2009
CONTROLLER, ENVIRONMENTAL SYSTEM	JC SYSTEMS	600-RTD	25-128	RTD ± 1.08°F, RH ± 1% RH	06/07/2009
TRANSMITTER, HUMIDITY & TEMPERATURE	VAISALA	HMP235	31-87	± 2% RH (3-96% RH)	04/05/2009

09-0623 Enc 1 Pg 13

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS AND RESTRAINT SYSTEM
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE HIGH TEMPERATURE
STORAGE AND OPERATION TEST
JOB NO. 410742-00-000 FILE NO. 09-0223 28 JANUARY 2009
DTB04R09-0623 ENCLOSURE 1 PHOTO 1

DAYTON T. BROWN INC.
Founded 1950

Enclosure 2

Humidity Test and Results

TEST REQUIREMENT

The humidity test shall be conducted in accordance with references (c) through (f).

TEST RESULTS

The humidity test was conducted on the following test items:

1. Oregon Aero Seat Cushion
2. Baseline Seat Cushion
3. Goodrich (Air Bladder) Seat Cushion
4. Oregon Aero Seat Back

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

The Goodrich (Air Bladder) Seat Cushion was successfully operated just prior to the end of the 6th cycle of the test.

Refer to the test data sheets on the following pages for the results of the humidity test.

The test items completed all phases of testing.

A post-test visual inspection of the test items revealed that all of the test items were very damp.

A post-test operational check of the Goodrich (Air Bladder) Seat Cushion revealed that the test item would appear to operate correctly immediately after being switched on; however, within a short period of time, the red and green lights would flash and the pump would stop operating. A second attempt resulted in the same outcome. A couple of additional functional tests were conducted (i.e. several hours after the completion of the humidity test and the following day); however, the Seat Cushion remained in a nonfunctioning state.

ALL TEMPERATURE IN DEGREES F

+/- 3.6 F

DAYTON T. BROWN INC.

Founded 1950

Job Number: 410742-00-000 Test: Humidity Date: 29 Jan 0?

TIME	TEST TIME HOURS	REQ TEMP F	ACTUAL TEMP F	REQ % RH	ACT % RH	REMARKS	TECH
1000	0	73	72.9	45 - 55	50.9		TD
1400	4	|	72.9	|	51.4		TD
1800	8	|	72.9	|	49.9		HE
2200	12	|	72.9	|	50.2		HE
0200	16	|	72.9	|	49.9		RS
0600	20	|	72.9	|	49.9		RS
1000	24	73	73.0	45-55	49.8		mm

John ???

ALL TEMPERATURE IN DEGREES F
+/- 3.6 F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: Humidity Date: 30 JAN 09

TIME	TEST TIME HOURS	REQ TEMP F	ACTUAL TEMP F	REQ % RH	ACT % RH	REMARKS	TECH
1030	0	86	86.2	91-99	92.3		mm
1230	2	140	139.8	|	94.5		mm
1430	4	|	140	|	94.7		mm
1630	6	|	139.8	|	94.6		VD
1830	8	140	139.6	91-99	94.7		VD
2030	10	|	127.1	85-100	94.9		VD
2230	12	|	111.7	|	94.4		VD
0030	14	|	99.0	85-100	95.0		VD
0230	16	86	86.7	91-99	95.1		VD
0430	18	|	85.8	|	94.4		VD
0630	20	|	85.8	|	94.5		MP
0830	22	|	85.8	|	95.0		MP
1030	24	86	86.0	91-99	95.0	Cycle 1 of 10	MP
1030	0	86	86.0	91-99	95.0		MP
1230	2	140	139.6	|	94.6		MP
1430	4	|	139.8	|	94.8		MP
1630	6	|	139.8	|	94.4		MP
1830	8	140	140.1	91-99	95.0		mm
2030	10	|	128.5	85-100	94.4		mm
2230	12	|	113.0	|	94.7		mm
0030	14	|	96.0	85-100	94.4		n
0230	16	86	86.6	91-99	94.5		n
0430	18	|	85.8	|	94.4		n
0630	20	|	85.8	|	94.1		n
0830	22	|	85.8	|	94.4		JP
1030	24	86	86.0	91-99	93.8	Cycle 2 of 10	JP

ALL TEMPERATURE IN DEGREES F
+/- 3.6 F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: Humidity Date: 1 FEB 09

TIME	TEST TIME HOURS	REQ TEMP F	ACTUAL TEMP F	REQ % RH	ACT % RH	REMARKS	TECH
1030	0	86	86.0	91-99	93.8		JP
1230	2	140	139.6	|	93.5		JP
1430	4	|	139.6	|	95.8		JP
1630	6	|	139.8	|	94.7		EW
1830	8	140	139.9	91-99	94.8		EW
2030	10	|	126.0	85-100	94.9		EW
2230	12	|	112.2	|	94.9		EW
0030	14	|	98.1	85-100	94.6		[illegible]
0230	16	86	86.0	91-99	94.9		[illegible]
0430	18	|	85.8	|	95.1		[illegible]
0630	20	|	86.0	|	94.3		[illegible]
0830	22	|	85.8	|	95.1		mm
1030	24	86	85.8	91-99	94.6	Cycle 3 of 10	mm
1030	0	86	85.8	91-99	94.6		mm
1230	2	140	139.8	|	94.7		mm
1430	4	|	139.8	|	94.6		mm
1630	6	|	140.0	|	94.9		VD
1830	8	140	140.0	91-99	94.8		VD
2030	10	|	126.0	85-100	94.8		VD
2230	12	|	112.0	|	94.2		VD
0030	14	|	98.0	85-100	95.0		[illegible]
0230	16	86	85.8	91-99	94.4		[illegible]
0430	18	|	85.8	|	94.6		[illegible]
0630	20	|	85.8	|	94.3		[illegible]
0830	22	|	85.8	|	94.9		mm
1030	24	86	85.7	91-99	94.6	Cycle 4 of 10	mm

ALL TEMPERATURE IN DEGREES F
+/- 3.6 F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: Humidity Date: 3 FEB 09

TIME	TEST TIME HOURS	REQ TEMP F	ACTUAL TEMP F	REQ % RH	ACT % RH	REMARKS	TECH
1030	0	86	85.7	91-99	94.6		mm
1230	2	140	140.0	|	94.6		mm
1430	4	|	139.8	|	95.0		mm
1630	6	|	139.8	|	94.7		VD
1830	8	140	139.3	91-99	94.6		VD
2030	10	|	126.5	85-100	94.8		VD
2230	12	|	111.9	|	94.3		VD
0030	14	|	97.6	85-100	94.7		A
0230	16	86	86.0	91-99	95.1		A
0430	18	|	86.0	|	95.2		A
* 0630	20	|	86.0	|	94.9		mm
0830	22	|	86.0	|	94.6		mm
1030	24	86	86.0	91-99	94.5	Cycle 5 of 10	mm
1030	0	86	86.0	91-99	94.5		mm
1230	2	140	140.0	|	95.0		mm
1430	4	|	140.0	|	95.0		mm
1630	6	|	139.6	|	94.5		VD
1830	8	140	139.8	91-99	94.7		VD
2030	10	|	128.0	85-100	94.7		VD
2230	12	|	111.4	|	95.1		VD
0030	14	|	97.8	85-100	94.3		A
0230	16	86	85.6	91-99	94.5		A
0430	18	|	85.8	|	94.5		A
0630	20	|	86.0	|	94.8		A
0830	22	|	85.8	|	95.1		R
1030	24	86	86.1	91-99	94.7	Open Chamber Cycle 6 of 10	JJ
						and Conduct Operational	

Check - Unit Ops OK

* OFF CHART

ALL TEMPERATURE IN DEGREES F
+/- 3.6 F

DAYTON T. BROWN INC.
Founded 1950
Page 5 of 6

Job No: 410742-00-000 Test: Humidity Date: 5 Feb 09

TIME	TEST TIME HOURS	REQ TEMP F	ACTUAL TEMP F	REQ % RH	ACT % RH	REMARKS	TECH
1030	0	86	86.1	91-99	94.7		[illegible]
1230	2	140	140.0		94.2		[illegible]
1430	4		140.0		94.5		[illegible]
1630	6		140.0		95.1		VD
1830	8	140	140.0	91-99	94.7		VD
2030	10		125.9	85-100	94.7		VD
2230	12		113.0		94.2		VD
0030	14		95.2	85-100	94.5		[illegible]
0230	16	86	86.0	91-99	94.8		[illegible]
0430	18		85.8		94.4		[illegible]
0630	20		85.8		93.9		[illegible]
0830	22		86.0		94.9		[illegible]
1030	24	86	86.0	91-99	94.8	Cycle 7 of 10	[illegible]
1030	0	86	86.0	91-99	94.8		[illegible]
1230	2	140	140.0		94.8		[illegible]
1430	4		140.0		94.9		MK
1630	6		139.6		95.3		VD
1830	8	140	139.8	91-99	94.8		VD
2030	10		126.1	85-100	94.3		VD
2230	12		112.9		94.7		VD
0030	14		95.7	85-100	94.9		MK
0230	16	86	85.8	91-99	94.6		MK
0430	18		85.8		94.5		MK
0630	20		85.6		94.9		MK
0830	22		85.8		94.5		SM
1030	24	86	85.8	91-99	94.2	Cycle 8 of 10	SM

ALL TEMPERATURE IN DEGREES F
+/- 3.6 F

DAYTON T. BROWN INC.
Founded 1950

Page 6 of 6

Job No: 410742-00-000 Test: Humidity Date: 7 Feb 09

TIME	TEST TIME HOURS	REQ TEMP F	ACTUAL TEMP F	REQ % RH	ACT % RH	REMARKS	TECH
1030	0	86	85.8	91-99	94.2		SM
1230	2	140	140.0	|	94.8		SM
1430	4	|	140.0	|	94.8		SM
1630	6	|	140.0	|	94.8		VD
1830	8	140	139.8	91-99	94.7		VD
2030	10	|	126.3	85-100	94.8		VD
2230	12	|	123.0	|	94.8		VD
0030	14	|	97.9	85-100	94.8		[illegible]
0230	16	86	85.8	91-99	94.9		[illegible]
0430	18	|	85.8	|	94.3		[illegible]
0630	20	|	85.8	|	94.9		[illegible]
0830	22	|	85.8	|	94.9		[illegible]
1030	24	86	86.0	91-99	95.1	Cycle 9 of 10	[illegible]
1030	0	86	86.0	91-99	95.1		[illegible]
1230	2	140	140.0	|	94.9		[illegible]
1430	4	|	139.8	|	94.5		[illegible]
1630	6	|	139.8	|	94.9		[illegible]
1830	8	140	140.0	91-99	94.5		[illegible]
2030	10	|	126.1	85-100	94.5		[illegible]
2230	12	|	111.9	|	94.6		[illegible]
0030	14	|	97.2	85-100	95.0		[illegible]
0230	16	86	86.0	91-99	94.7		[illegible]
0430	18	|	85.8	|	94.6		[illegible]
0630	20	|	86.0	|	94.6		[illegible]
0830	22	|	85.8	|	94.4		[illegible]
1030	24	86	85.8	91-99	94.1	Cycle 10 of 10	[illegible]

[illegible]

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: **410742-00** **TEST: HUMIDITY**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, TEMPERATURE/HUMIDITY	THERMOTRON	9MX-64-705-810C	04E-010	N/A	N.C.R.
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-4	TYPE T ± 0.7° F; RH ± 0.2% RH	05/31/2009
CONTROLLER, ENVIRONMENTAL SYSTEM	JC SYSTEMS	600	25-68	RTD ± 1.08°F; RH ± 1.0% RH	05/31/2009

09-0623 Enc 2 Pg 8

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE HUMIDITY TEST

JOB NO. 410742-00-000	FILE NO. 09-10183	28 JANUARY 2009
DTB04R09-0623	ENCLOSURE 2	PHOTO 1

DAYTON T. BROWN INC.
Founded 1950

Enclosure 3

Low Temperature Storage and Operation Test and Results

09-0623

TEST REQUIREMENT

The low temperature storage and operation test shall be conducted in accordance with references (c) through (f).

TEST RESULTS

The low temperature storage and operation test was conducted on the following test items:

1. Oregon Aero Seat Cushion, Serial No. 103926
2. Baseline Seat Cushion, Serial No. 2A
3. Goodrich (Air Bladder) Seat Cushion
4. Oregon Aero Seat Back, Serial No. 103966
5. Restraint System

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

Refer to the test data sheets on pages 3 and 4 of this enclosure for the results of the low temperature storage test.

An operational check of the Goodrich (Air Bladder) Seat Cushion and the Restraint System after the completion of the low temperature storage test revealed that both test items appeared to be functioning correctly after this test. Specifically, the Goodrich (Air Bladder) Seat Cushion pump continued to cycle on and off as required. Additionally, the belt of the Restraint System was pulled completely out and subsequently released which resulted in the automatic retraction of the belt.

The Goodrich (Air Bladder) Seat Cushion and the Restraint System was operated during the low temperature operation test.

Refer to the test data sheet on page 5 of this enclosure for the results of the low temperature operation test.

The test items completed all phases of testing. During the operational check at low temperature, the Goodrich (Air Bladder) Seat Cushion did not work correctly. Specifically, when the Cushion was turned on, it immediately started flashing red and green lights and the pump did not operate. Additionally, the belt of the Restraint System was pulled completely out at the low temperature and subsequently released which resulted in the automatic retraction of the belt; however, the time for the belt to retract was very long (i.e. approximately 30 seconds).

A post-test visual inspection of the test items revealed no anomalies due to testing.

A post-test operational check of the Goodrich (Air Bladder) Seat Cushion and the Restraint System revealed that both items appeared to be functioning correctly after this test. Specifically, the Goodrich (Air Bladder) Seat Cushion pump continued to cycle on and off as required. Additionally, the belt of the Restraint System was pulled completely out and subsequently released which resulted in the automatic retraction of the belt.

All Temperature Measured in Degrees F

DAYTON T. BROWN INC.

Founded 1950

Page 1 of 3

Job No: 410742-00-000 Test: Low Temperature Storage Date: 7FEB09

TIME	Req. Cham. Amb.	Actual Cham. Amb.	Hours of 72	Remarks	TECH
1250	-65	77.0	/	start to temp	BM
1315	|	62.5	0	start soak	SM
1615	|	-65.0	3		VD
1715	|	-64.9	4		VD
1915	|	-64.8	6		VD
2115	|	-64.8	8		VD
2315	|	-64.8	10		VD
0115	|	-65.0	12		[illegible]
0315	|	-65.0	14		[illegible]
0515	|	-65.0	16		[illegible]
0715	|	-65.0	18		[illegible]
0915	|	-65.2	20		[illegible]
1115	|	-65.0	22		[illegible]
1315	|	-64.7	24		[illegible]
1515	|	-65.0	26		[illegible]
1715	|	-64.8	28		[illegible]
1915	|	-64.8	30		[illegible]
2115	|	-65.0	32		[illegible]
2315	|	-64.7	34		[illegible]
0115	|	-64.8	36		[illegible]
0315	|	-64.8	38		[illegible]
0515	|	-64.7	40		[illegible]
0715	|	-64.8	42		[illegible]
0915	|	-65.0	44		[illegible]
1115	|	-64.8	46		[illegible]
1315	|	-64.8	48		[illegible]
1515	-65	-64.8	50		[illegible]

DAYTON T. BROWN INC.
Founded 1950

All Temperature Measured in Degrees F

Page 2 of 3

Job No: 410742-00-000 Test: Low Temperature Storage Date: 9FEB09

TIME	Req. Cham. Amb.	Actual Cham. Amb.	Hours of 72	Remarks	TECH
1715	-65	-64.8	52		VD
1915	|	-64.7	54		VD
2115	|	-65.2	56		VD
2315	|	-64.8	58		VD
0115	|	-64.8	60		[illegible]
0315	|	-64.7	62		[illegible]
0515	|	-65.0	64		[illegible]
0715	|	-65.0	66		[illegible]
0915	|	-65.0	68		[illegible]
1115	|	-64.7	70		Mon
1315	|	-64.8	72	END TEST / GOTO R/T	[illegible]
1400	|	77.6		@ R/T	[illegible]
2/11/09 0920	|	—	—	OPERATIONAL CHECK CONDUCTED	
	|			ON RESTRAINT SYSTEM AND	
	|			SEAT CUSHION - NO ANOMALIES	
	|			[illegible]	
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	-65				

All Temperature Measured in Degrees F

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: Low Temperature Operation Date: 2/11/09

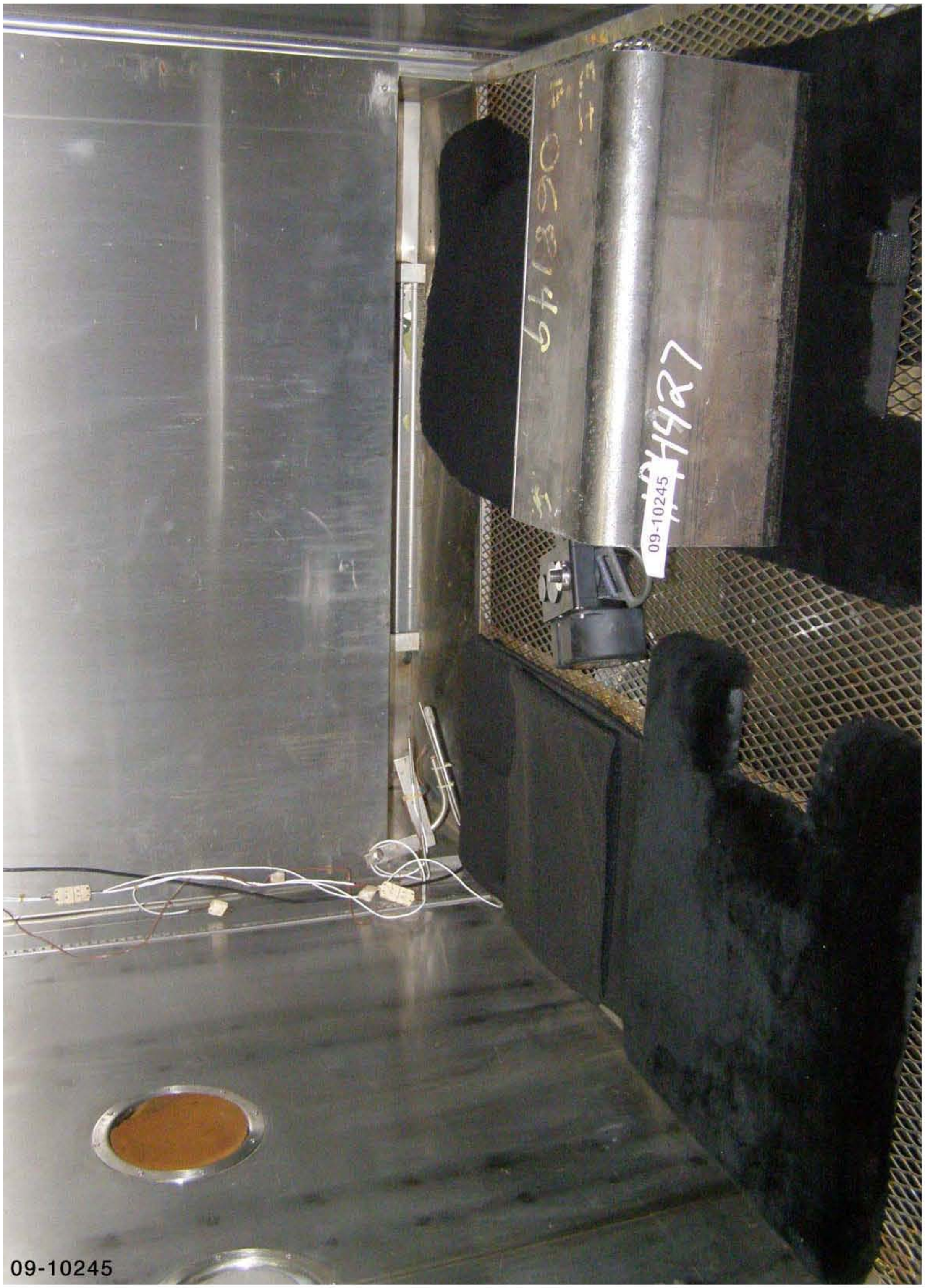
TIME	Req. Cham. Amb.	Actual Cham. Amb.	Hours of ~~72~~ 2 hr	Remarks	TECH
1006	-40 ~~-65~~	-40.0	0	@ -40°. Await unit stab.	[illegible]
1040	|	-40.2	0	UNIT AT -38.4°F START 2HR SOAK	[illegible]
1140	|	-40.7	1		[illegible]
1240	|	-40.9	2	END SOAK, ENG TO PERFORM OPS	[illegible]
1245	|	-41.0	—	OPS Check conducted	
	|			Restraint system - belt took	
	|			approximately 30 seconds to	
	|			retract.	
	|			Seat Cushion flashes red	
	|			and green - pump does not	
	|			come on [initials]	
1255	|	—	—	GO TO 90°F PER ENG. HOLD FOR 30 mins	[illegible]
1305	|	90.0	—	~~@ Amb~~ @ 90°F	[illegible]
1335	|	90.1	—	ENG TO PERFORM OPS CHECK	[illegible]
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	|				
	~~-65~~				

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: **410742-00** **TEST: LOW TEMPERATURE STORAGE AND OPERATION**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, TEMPERATURE/HUMIDITY	RUSSELL	RD-64-705-705	04E-007	N/A	N.C.R.
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-13	RTD ± 0.5°F, RH ± 0.2% RH	08/16/2009
CONTROLLER, ENVIRONMENTAL SYSTEM	JC SYSTEMS	600-RTD	25-128	RTD ± 1.08°F, RH ± 1% RH	06/07/2009
TRANSMITTER, HUMIDITY & TEMPERATURE	VAISALA	HMP235	31-87	± 2% RH (3-96% RH)	04/05/2009

09-0623 Enc 3 Pg 5



TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS AND RESTRAINT SYSTEM
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE LOW TEMPERATURE
STORAGE AND OPERATION TEST

JOB NO. 410742-00-000	FILE NO. 09-10245	7 FEBRUARY 2009
DTB04R09-0623	ENCLOSURE 3	PHOTO 1

Enclosure 4

Altitude Test and Results

TEST REQUIREMENT

The altitude test shall be conducted in accordance with reference (e).

TEST RESULTS

The altitude test was conducted on one Goodrich (Air Bladder) Seat Cushion, Serial No. 21.

A pretest visual inspection of the test item revealed no anomalies.

A pretest operational check of the test item revealed that this test item appeared to be functioning correctly. Specifically, the test item pump continued to cycle on and off as required.

All testing was performed in accordance with the referenced specification.

The test item was operated during the test. Note: The test item battery was changed after each 250 humidity cycles (i.e. approximately every 48 hours) during this test as directed by S. Fleming (United States Air Force). The test item was found to be operating correctly (i.e. the pump continued to cycle on and off as required) just prior to changing the battery after 250 cycles, 500 cycles, and 750 cycles.

Refer to the test data sheets on the following pages for the results of the altitude test.

The test item completed all phases of testing.

A post-test visual inspection of the test item revealed that the red and green lights were flashing and the test item pump was not operating (i.e. the pump was not cycling on and off). Subsequently the switch on the test item was cycled off then on and the test item subsequently appeared to be operating correctly again.

DAYTON T. BROWN INC.
Founded 1950

Page 1 of 4

Job No: 410742-00-000

Test: ~~Low Temperature~~ Altitude

Date: 9 Feb 09

TIME	Chamber Ambient F	Chamber Pressure "Hg	Cycles of 1000	Remarks	TECH
1320	79.0	28.7	0	Start cycle	MC
1338	77.6	19.0	2		RC
1723	76.5	28.5	22		VD
1940	76.8	19.0	35		VD
2115	76.5	28.6	43		VD
0010	78.4	28.3	59		VD
0220	75.2	28.4	71		[illegible]
0420	77.2	19.0	81		[illegible]
0600	75.6	28.5	91		[illegible]
0740	76.1	28.6	100		[illegible]
0940	75.9	19.0	111		RC
1140	77.5	28.5	122		MP
1425	76.5	19.0	136		RC
1620	77.2	28.6	147		RC
—	—	—	—		—
1635	76.8	28.7	147	Resume Cycling	RC
1725	77.4	19.1	151		RC
1910	77.4	28.4	161		VD
2043	76.5	19.4	170		VD
2350	77.8	28.5	187		VD
0034	76.1	19.2	190		[illegible]
0255	71.6	28.2	203		[illegible]
0445	77.4	19.1	212		[illegible]
0620	77.5	28.3	222		[illegible]
0835	76.8	23.5	234		SM
1130	76.8	28.5	250	OPS CHECK - OK - CHG BATTERY	SM
1156	77.6	30.0	250	Start cycling	SM
1440	77.4	19.3	266		SM
1635	76.5	28.3	276		VD
2112	77.9	28.4	301		VD
0030	76.8	28.1	319		VD

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: ~~Low Temperature~~ Altitude Date: 12FEB09

TIME	Chamber Ambient F	Chamber Pressure "Hg	Cycles of 1000	Remarks	TECH
0240	77.9	28.1	331		
0404	77.0	18.8	338		
0613	78.3	28.5	350		
0656	78.2	19.0	359		
1050	82.2	21.2	375		SM
1600	86.4	24.3	403		SM
1800	89.1	22.1	412		HE
2000	93.0	21.4	425		HE
2200	94.1	24.1	436		HE
2210	95.0	28.7	437	STOP CYCLING - TEMP HIGH.	VD
2220	91.9	28.7	438	RESET CONTROLLER OUTPUT, TEMP DECREASING - RESUME	VD
2231	87.8	28.6	439		VD
2321	77.5	19.1	443	TEMP AT 77°F	VD
0104	79.2	28.6	452		
0335	78.1	19.0	465		
0424	78.6	28.4	470		
0634	79.2	19.0	481		
0720	79.2	28.6	486		
0855	78.8	29.7	500	await ops check	SM
—	—	—	—	OPS CHK - OK - CHG Battery	
1300	77.7	28.4	500	Restart cycling	
1530	81.6	21.7	513		SM
1810	94.8	21.6	528		
1913	97.5	28.4	534	TEMP HIGH - STOP TEST RUN & SECURE CHAMB. @ RM AMB CONDS. PER INSTR.	VD
—	—	—	—	HOLD OFF FOR COOLING REPAIRS	VD
	17 FeB 09				
1405	77.2	28.8	535	Resume Cycling	Re
1530	73.9	20.5	542		
1823	77.4	28.4	558		VD
2007	76.5	19.5	568		VD
2308	77.8	28.7	584		VD

DAYTON T. BROWN INC.
Founded 1950

Job No: 410742-00-000 Test: ~~Low Temperature~~ Altitude Date: 18 Feb 03 04

TIME	Chamber Ambient F	Chamber Pressure "Hg	Cycles of 1000	Remarks	TECH
0116	77.5	28.8	594		
0210	76.8	19.1	600		
0425	78.1	28.5	612		
0553	76.6	19.0	628		
0830	78.3	28.4	635		SM
1120	77.2	19.0	651		
1625	78.6	23.6	677		SM
1831	76.5	19.3	693		VD
2020	75.6	19.1	703		VD
2154	78.1	28.3	711		VD
2300	76.9	28.4	717		VD
0033	77.2	19.0	725		
0157	77.9	28.5	733		
0415	77.9	19.2	745		
0504	77.5	29.4	750	HOLD FOR OPS	
0830	78.4	28.6	750		mm
0845	78.6	26.8	752	STOP FOR OPS	mm
0915	78.9	26.9	752	START TEST	mm
1020	78.9	19.7	758		mm
1220	76.3	21.0	770		mm
1530	77.0	26.1	786		mm
1615	77.2	28.8	790		VD
1808	77.0	19.0	801		VD
2100	77.3	28.7	816		VD
2316	77.4	19.2	829		VD
0045	76.6	19.0	837		
0138	76.6	28.4	841		
0357	77.0	28.7	854		
0504	78.1	19.1	860		
0647	77.0	28.6	869		
0910	76.8	22.0	882		mm

DAYTON T. BROWN INC.
Founded 1950

Page 4 of 4

Job No: 410742-00-000 Test: ~~Low Temperature~~ Altitude JB Date: 20 FEB 09

TIME	Chamber Ambient F	Chamber Pressure "Hg	Cycles of 1000	Remarks	TECH
1020	77.7	24.1	888		mm
1245	76.8	22.0	903		mm
1545	79.0	26.7	920		mm
1722	76.8	28.3	927		VD
2029	76.7	28.1	944		VD
2308	76.8	19.1	~~958~~ VD 959		VD
0100	76.5	19.9	968		HE
0405	76.6	22.6	985		HE
0709	77.5	30.2	1000	TEST complete.	HE

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: 410742-00 **TEST: ALTITUDE**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, TEMPERATURE / ALTITUDE	DAYTON T. BROWN	RELIABILITY	04E-003	N/A	N.C.R.
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-10	RTD ± 0.5°F, ALT. ± 0.1% HG + 1 LSD	06/21/2009
CONTROLLER, ENVIRONMENTAL SYSTEM	JC SYSTEMS	600A	25-150	RTD ± 1.08°F, ± 1% + 1 DIG. "HG	06/28/2009
TRANSDUCER, PRESSURE 0 - 32 IN HG	HEISE	HPO	40-26	± 0.3% OF FULL SCALE	05/31/2009

09-0623 Enc 4 Pg 6

TESTED FOR UNITED STATES AIR FORCE
ITEM: GOODRICH (AIR BLADDER) SEAT CUSHION
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE ALTITUDE TEST
JOB NO. 410742-00-000 FILE NO. 09-10247 9 FEBRUARY 2009
DTB04R09-0623 ENCLOSURE 4 PHOTO 1

DAYTON T. BROWN INC.
Founded 1950

Enclosure 5

Blowing Dust Test and Results

TEST REQUIREMENT

The blowing dust test shall be conducted in accordance with references (c) through (f).

TEST RESULTS

The blowing dust test was conducted on the following test items:

1. Oregon Aero Seat Cushion, Serial No. 103926
2. Baseline Seat Cushion, Serial No. 4A
3. Goodrich (Air Bladder) Seat Cushion, Serial No. 17
4. Oregon Aero Seat Back, Serial No. 103966

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

The Goodrich (Air Bladder) Seat Cushion was nonoperating during testing.

Refer to the test data sheets on the following pages for the results of the blowing dust test.

The test items completed all phases of testing.

A post-test visual inspection of the test items revealed a light coating of dust on all exterior surfaces of the test items.

A post-test operational check of the Goodrich (Air Bladder) Seat Cushion revealed that the Goodrich (Air Bladder) Seat Cushion does not appear to be working (i.e., flashes red and green lights and pump does not turn on). An attempt to change the battery was thwarted when the zipper on the cushion could not be opened due to the penetration of the dust.

MIL-STD-810F
DUST
DATA

DAYTON T. BROWN INC.
Founded 1950

JOB NO: 410742-00-000

DATE: 10 FEB 09

ITEM: Seat Cushion Seat Cushion
Seat Cushion

PAGE 1 OF 3

TIME	HRS INTO TEST	°F AIR +/- REQ	TEMP 3.6 F ACTUAL	RELATIVE % HUMIDITY % REQ	ACTUAL	AIR VELOCITY FT/MIN FLOW +/- TOL. 175 ft/min REQ	ACTUAL	DUST DENSITY GRAMS PER CUBIC FOOT +/- TOL. 0.2 REQ	ACTUAL	REMARKS	TECH
1130	0	77	75.8	<30%	18.6	1750	1776	0.3	0.22	Begin TEST	Mm
1230	1	|	76.6	<30%	18.2	|	1850	|	0.14		Mm
1330	2	|	77.0	<30%	18.6	|	1844	|	0.14		Mm
1430	3	|	77.1	<30%	19.2	|	1808	|	0.155		Mm
1530	4	|	76.6	<30%	19.1	|	1808	|	0.150		Mm
1630	5	|	76.7	<30%	19.2	|	1858	|	0.150		VD
1730	6	77	76.9	<30%	19.4	1750	1821	0.3	0.150	Goto 160°F	VD

REMARKS:

MIL-STD-810 F
DUST
DATA

DAYTON T. BROWN INC.
Founded 1950

JOB NO: 410742-00-000

DATE: 10Feb09

ITEM: Seat Cushion Seat Cushion
Seat Cushion

PAGE 2 OF 3

TIME	Test Hours	AIR +/- REQ	TEMP 3.6 F ACUAL	RELATIVE % HUMIDITY % REQ	ACTUAL	AIR VELOCITY FT/MIN FLOW TOL. REQ	ACTUAL	DUST GRAMS CUBIC TOL. REQ	Unit Temp	REMARKS	TECH
1845	0	160	159.8	<30%	3.6	>295	478	N/A	—	BEGIN 1 HR. STAB. SOAK	VD
1945	1	160	160.1	<30%	3.2	>295	499	N/A	—	END SOAK	VD

MIL-STD-810F
DUST
DATA

DAYTON T. BROWN INC.
Founded 1950

JOB NO: 410742-00-000

DATE: 10 FEB 09

PAGE 3 OF 3

ITEM: Seat Cushion Seat Cushion
Seat Cushion

TIME	HRS INTO TEST	AIR +/- REQ (°F)	TEMP 3.6 ACT (°F)	RELATIVE % HUMIDITY % REQ	RELATIVE % HUMIDITY % ACTUAL	AIR VELOCITY FT/MIN FLOW TOL. +/- 175 REQ	AIR VELOCITY FT/MIN FLOW TOL. +/- 175 ACTUAL	DUST DENSITY GRAMS PER CUBIC FOOT TOL. +/- 0.2 REQ	DUST DENSITY GRAMS PER CUBIC FOOT TOL. +/- 0.2 ACTUAL	REMARKS	TECH
2000	0	160	160.0	<30%	3.1	1750	1825	0.3	0.280		VD
2100	1	|	159.8	|	3.6	|	1847	|	0.155		VD
2200	2	|	159.9	|	3.8	|	1813	|	0.155		VD
2300	3	|	160.1	|	3.7	|	1831	|	0.150		VD
2400	4	|	160.0	|	3.7	|	1824	|	0.150		VD
0100	5	|	160.0	|	3.5	|	1860	|	0.150		S
0200	6	160	159.9	<30%	3.4	1750	1866	0.3	0.150		S

REMARKS:

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

DAYTON T. BROWN INC. Founded 1950

Job Sub: 410742-00 **TEST: BLOWING DUST**

09-0623 Enc 5 Pg 6

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, SAND AND DUST	TENNY	13 FT	04E-024	N/A	N.C.R.
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-2	RTD ± 0.5°F, RH ± 0.2 RH, VOLTS ± 0.05% + 1D	11/29/2009
CONTROLLER, UNIVERSAL DIGITAL	HONEYWELL	UDC 5000	25-44	± 0.05% F.S.	06/14/2009
CONTROLLER, UNIVERSAL DIGITAL	HONEYWELL	UDC 5000	25-80	± 1.0° F	03/01/2009
TRANSMITTER, HUMIDITY AND TEMPERATURE	VAISALA	HMP235	31-129	±2.0% RH FROM 3 TO 96%	05/17/2009
PROBE, RTD 3-WIRE 100 OHMS	OMEGA	PR-13-2-100-1/4-24-E	39-27	MFR	12/27/2009
PROBE, RTD 3-WIRE 100 OHMS	OMEGA	PR-13-2-100-1/4-24-E	39-28	MFR	12/27/2009
AIR VELOCITY SYSTEM	KURZ	155JR	43-7	MFR	05/03/2009

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE BLOWING DUST TEST
JOB NO. 410742-00-000 FILE NO. 09-10249 10 FEBRUARY 2009
DTB04R09-0623 ENCLOSURE 5 PHOTO 1

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
POST-BLOWING DUST TEST VIEW OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-10253 11 FEBRUARY 2009
DTB04R09-0623 ENCLOSURE 5 PHOTO 2

DAYTON T. BROWN INC.
Founded 1950

Enclosure 6

Salt Fog Test and Results

TEST REQUIREMENT

The salt fog test shall be conducted in accordance with references (c) and (d).

TEST RESULTS

The salt fog test was conducted on the following test items:

1. Oregon Aero Seat Cushion, Serial No. 103926
2. Baseline Seat Cushion, Serial No. 2A
3. Goodrich (Air Bladder) Seat Cushion
4. Oregon Aero Seat Back, Serial No. 103966
5. Restraint System

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

The test items were nonoperating during testing.

Refer to the test data sheets on the following pages for the results of the salt fog test.

The test items completed all phases of testing.

A post-test visual inspection of the test items revealed the following.

1. There are salt deposits on all of the test items.
2. There is some minor corrosion on some of the snaps and zippers of the test items.
3. There is some significant corrosion on some of the subcomponents of the Restraint System.

A post-test operational check of the Goodrich (Air Bladder) Seat Cushion revealed that the pump continued to cycle on and off as required.

SALT FOG COLLECTION DATA

DAYTON T. BROWN INC.
Founded 1950

JOB No: 410742-00-000

DATE: 11 FeB 09

ITEM: Seat Cushion

SERIAL#: See Pretest Check

PAGE 1 OF 1

TEST PARAMETERS					
	SPECIFICATION	SPECIFIC GRAVITY @ 77 F	TEMP TOL	COLL. RATE ML/HR	PH @ 95F
	MIL-STD-202G Meth.101E	1.0255 TO 1.0400	+/- 5 F	0.5-3.0	6.5 - 7.2
	MIL-STD-810 D,E	1.0255 TO 1.0400	+/- 3.6F	0.5-3.0	6.5 - 7.2
X	MIL-STD-810F	1.0255 TO 1.0400	+/- 4.0 F	1.0-3.0	6.5 - 7.2
	FED-STD-151A @ 5%	1.0260 TO 1.0413	+2, -3	0.75-2.0	6.5 - 7.2
	FED-STD-151A @ 20%	1.1260 TO 1.1570	+2,-3	0.75-2.0	6.5 - 7.2
	ASTM B117	1.0255 TO 1.0400	+2, -3	1.0-2.0	6.5 - 7.2
	RTCA/DO-160C	1.0220 TO 1.041	+/- 5.4	0.5-3.0	6.5 - 7.2
	GMW3112GS-5-1-V-1 BASELINE	1.0053 TO 1.0125	+/- 3.6	1.0 - 2.0	6.5 - 7.2

WATER DATA: WATER TYPE DEIONIZED

CONDUCTIVITY MEASUREMENT ______ (MUST BE 4.0 MicS or Less)

DATE OF MEASUREMENT ______

PRETEST SPECIFIC GRAVITY: ______

PRETEST pH: ______

DATE AND TECH	SPRAY START STOP	TOTAL COLL. HOURS	COLLECTION RATE ML/DISH ML/DISH/HOUR				SPECIFIC GRAVITY @ 95 F RES	COLL	pH OF SOLLUTION RES	COLL
11 FeB 09 JM	1615	24	52	36	30	33	1.036	1.035	6.64	6.79
12 Feb 09 SP	1615		2.16	1.40	1.25	1.37				
		24	40	38	30	55	1.035	1.036	6.98	7.15
14 Feb 09 [illegible]	1630		1.67	1.58	1.25	2.29				

ENGINEER [signature]

09-0623 Enc 6 Pg 2

DAYTON T. BROWN INC.
Founded 1950

Page 1 of 5

JOB No.: 410742-00-000

DATE: 11FEB09

ITEM: Seat Cushion | Seat Cushion

TIME	Chamber Ambient F	Hours Into Soak	REMARKS	TECH
1345	82.3	—	start to temp	SM
1400	94.3	0	start 2hr soak	SM
1500	95.0	1		SM
1600	95.8	2		SM
1615	94.2	2.15	start spray	SM

ENGINEER

09-0623 Enc 6 Pg 3

JOB No.: 410742-00-000

DATE: 11 FEB 09

Seat Cushion

ITEM: Seat Cushion

SALT FOG DATA

DAYTON T. BROWN INC. Founded 1950

Page 2 of 5

TIME	HOUR INTO TEST	CHAM AMB F	AIR PRESS PSI	WATER TEMP F	TOWER LEVEL	SALT RES LEVEL	INT
1615	0	94.2	15 15	121.0 116.0	✓ ✓	✓	JM
1815	2	95.4	15 15	119.4 115.2	✓ ✓	✓	VD
2015	4	95.3	15 15	119.0 114.1	✓ ✓	✓	VD
2215	6	95.2	15 15	117.4 115.4	✓ ✓	✓	VD
0015	8	95.0	15 15	119.8 113.9	✓ ✓	✓	VD
0215	10	95.0	15 15	118.9 115.0	✓	✓	[illegible]
0415	12	95.5	15 15	118.3 113.4	✓	✓	[illegible]
0615	14	95.3	15 15	120.2 115.2	✓	✓	[illegible]
0815	16	95.2	15 15	118.5 118.9	✓ ✓	✓	[illegible]
1015	18	95.4	15 15	118.8 114.1	✓ ✓	✓	JP
1215	20	95.2	15 15	118.0 113.7	✓ ✓	✓	JP
1415	22	95.2	15 15	116.6 113.3	✓ ✓	✓	JP
1615	24	95.4	15 15	118.0 114.6	✓ ✓	✓	JP

COMMENTS:

ENGINEER [signature]

DAYTON T. BROWN INC.
Founded 1950

JOB NO: 410742-00-000

DATE: 12 Feb 09

ITEM: Seat Cushion 2A

Seat Cushion

PAGE 3 OF 5

TIME	TIME INTO TEST	REQ. TEMP F	ACT TEMP F	REQ. %RH	ACT %RH	REMARKS	TECH
1625	0	77 +/- 18	72.1	~~45-50~~ 55	49.9		JP
2025	4	|	76.3	|	49.3		HE
0025	8	|	76.7	|	49.7		VD
0425	12	|	76.6	|	50.3		LS
0825	16	|	76.8	|	48.8		mo
1225	20	|	76.8	|	49.7		JP
1625	24	77 +/- 18	76.1	~~45-50~~ 55	49.6		JP

ENGINEER [signature]

JOB No.: 410742-00-000

DATE: 13 Feb 09

Seat Cushion

ITEM: Seat Cushion

SALT FOG DATA

DAYTON T. BROWN INC. Founded 1950

Page 4 of 5

TIME	HOUR INTO TEST	CHAM AMB F	AIR PRESS PSI	WATER TEMP F	TOWER LEVEL	SALT RES LEVEL	INT
1630	0	94.4	15 15	117.8 111.4	✓ ✓	✓	JP
1830	2	95.2	15 15	120.0 114.3	✓ ✓	✓	[illegible]
2030	4	95.5	15 15	118.3 114.9	✓ ✓	✓	[illegible]
2230	6	95.4	15 15	119.4 114.3	✓ ✓	✓	[illegible]
0030	8	95.3	15 15	116.9 109.7	✓ ✓	✓	VD
0230	10	95.1	15 15	118.4 114.0	✓ ✓	✓	VD
0430	12	95.2	15 15	119.3 113.5	✓ ✓	✓	VD
0630	14	95.1	15 15	117.7 112.3	✓ ✓	✓	SM
0830	16	95.4	15 15	118.2 114.6	✓ ✓	✓	SM
1030	18	95.2	15 15	117.5 113.5	✓ ✓	✓	SM
1230	20	94.8	15 15	118.1 114.5	✓ ✓	✓	JM
1430	22	95.2	15 15	117.6 113.8	✓ ✓	✓	SM
1630	24	95.4	15 15	119.4 113.8	✓ ✓	✓	[illegible]

COMMENTS:

ENGINEER [signature]

DAYTON T. BROWN INC.
Founded 1950

JOB NO: 410742-00-000

DATE: 14 Feb 09

ITEM: Seat Cushion 2A

Seat Cushion

PAGE 5 OF 5

TIME	TIME INTO TEST	REQ. TEMP F	ACT TEMP F	REQ. %RH	ACT %RH	REMARKS	TECH
1655	0	77 +/- 18	76.1	45-55	50.6		[illegible]
2055	4	|	76.6	|	50.3		[illegible]
0055	8	|	76.1	|	49.7		[illegible]
0455	12	|	76.8	|	49.1		[illegible]
0855	16	|	75.9	|	48.2		[illegible]
1255	20	|	76.6	|	49.9		[illegible]
1655	24	77 +/- 18	77.2	45-55	49.2		[illegible]

ENGINEER [signature]

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: 410742-00 **TEST:** SALT FOG

09-0623 Enc 6 Pg 8

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, SALT FOG	DAYTON T. BROWN	21 FT	04E-021	N/A	N.C.R.
RECORDER, TEMPERATURE	DORIC	205	12-219	± 1.0° F	12/20/2009
CONTROLLER, UNIVERSAL DIGITAL	HONEYWELL	UDC 3000	25-40	± 2.0° F	05/31/2009
HYDROMETER, SPECIFIC GRAVITY 1.000 - 1.070 IN 0.001 DIVISION	FISHER SCIENTIFIC	11-556F	39-30	± 2% F.S.	N.P.C.R.
PH METER, PH/MV/°C	OAKTON	PH 510 SERIES	59-12	± 0.1 PH	CAL BEFORE USE
GAUGE, 60 PSI	WEISS	60 PSI	60-171	± 1.0 % FS	05/03/2009
GAUGE, 60 PSI	WEISS	60 PSI	60-173	± 1.0 % FS	05/03/2009
PYREX DISH, CRYSTALLIZING 100 x 50 mm	CORNING	NO. 3140	64-385	DATA	N.P.C.R.
PYREX DISH, CRYSTALLIZING 100 x 50 mm	CORNING	NO. 3140	64-385	DATA	N.P.C.R.
PYREX DISH, CRYSTALLIZING 100 x 50 mm	CORNING	NO. 3140	64-385	DATA	N.P.C.R.
PYREX DISH, CRYSTALLIZING 100 x 50 mm	CORNING	NO. 3140	64-385	DATA	N.P.C.R.
GRADUATED CYLINDER, 100 ML	FISHER SCIENTIFIC	08-557D	64-390	± 1ML	04/26/2009
CONTROLLER, CONDUCTIVITY W/ PROBE	OAKTON	1000 SERIES	92-5	± 3.5% OF F.S.	03/08/2009

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS AND RESTRAINT SYSTEM
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE SALT FOG TEST
JOB NO. 410742-00-000 FILE NO. 09-0428 11 FEBRUARY 2009
DTB04R09-0623 ENCLOSURE 6 PHOTO 1

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS AND RESTRAINT SYSTEM
CLOSE-UP POST-SALT FOG TEST VIEW OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-10273 17 FEBRUARY 2009
DTB04R09-0623 ENCLOSURE 6 PHOTO 4

DAYTON T. BROWN INC.
Founded 1950

Enclosure 7

Blowing Sand Test and Results

TEST REQUIREMENT

The blowing sand test shall be conducted in accordance with references (c) through (f).

TEST RESULTS

The blowing sand test was conducted on the following test items:

1. Oregon Aero Seat Cushion, Serial No. 103926
2. Baseline Seat Cushion, Serial No. 4A
3. Goodrich (Air Bladder) Seat Cushion, Serial No. 14
4. Oregon Aero Seat Back, Serial No. 103966

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

The test items were nonoperating during testing.

Refer to the test data sheet on the following pages for the results of the blowing sand test.

The test items completed all phases of testing.

A post-test visual inspection of the test items revealed the following.

1. There is a significant amount of sand embedded in the fabric of the test items.
2. The zipper works on the Goodrich (Air Bladder) Seat Cushion.

A post-test operational check of the Goodrich (Air Bladder) Seat Cushion revealed that the Goodrich (Air Bladder) Seat Cushion does not appear to be working (i.e., flashes red and green lights and the pump does not turn on).

Sand Data

DAYTON T. BROWN INC.
Founded 1950

PAGE 1 OF 1

DATE: 16 FEB 09

JOB NO.: 410742-00-000 TEST: Blowing Sand

Temperature: 160 F +/- 3.6
Humidity: 30% OR LESS
Air Velocity: 3540 +/- 250 ft/min. Actual Velocity: FT/MIN (AVE)
Sand Density: 2.2 g/m³ +/- 0.5 g/m³

TIME	TEST TIME (Min)	CHAM TEMP °F	UNIT TEMP °F	CHAM RH %	REMARKS	TECH
1035	0	157.4	—	3.8	BEGIN TEST	mm
1105	30	160.8	—	3.0		mm
1135	60	162.9	—	2.5		mm
1205	90	163.0	—	2.4	END FIRST PAIR	mm
1210	0	157.3	—	0.9	BEGIN LAST PAIR	mm
1240	30	160.3	—	1.4		mm
1310	60	161.5	—	1.9		mm
1340	90	160.8	—	1.1	END TEST	mm

SAND.BASIC

John

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Founded 1950

Job Sub: 410742-00 **TEST: BLOWING SAND**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
SAND BOX	DAYTON T. BROWN	40 FT	04E-025	N/A	N.C.R.
CONTROLLER, UNIVERSAL DIGITAL	HONEYWELL	UDC 3000	25-88	± 1.7° F	03/15/2009
TRANSMITTER, HUMIDITY AND TEMPERATURE	VAISALA	HMP235	31-86	± 2% FROM 10 TO 95% RH	03/29/2009
TIMER	DIMCO-GRAY	171	47-163	± 1 SECOND	05/03/2009
MONITOR, TEMPERATURE & PROCESS	OMEGA	DPI 8	9-138	± 0.3% OF READING	08/23/2009

09-0623 Enc 7 Pg 3

Enclosure 8

Fungus Test and Results

09-0623

TEST REQUIREMENT

The fungus test shall be conducted in accordance with references (c) and (d).

TEST RESULTS

The fungus test was conducted on the following test items:

1. Oregon Aero Seat Cushion, Serial No. C
2. Baseline Seat Cushion
3. Goodrich (Air Bladder) Seat Cushion, Serial No. 23
4. Oregon Aero Seat Back, Serial No. 103966 C

A pretest visual inspection of the test items revealed no anomalies.

All testing was performed in accordance with the referenced specifications.

The test items were nonoperating during testing.

Refer to the test data sheets on the following pages for the results of the fungus test.

The test items completed all phases of testing.

A post-test visual inspection of the test items revealed the following (see Photos 2 through 7 of this enclosure).

1. The Oregon Aero Seat Cushion, Baseline Seat Cushion, and Oregon Aero Seat Back have a significant amount of fungus growth on all of the external surfaces.
2. The Goodrich (Air Bladder) Seat Cushion has one small area with some fungal growth.

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Job Number: 410742-00-000 **Test:** Fungus **Date:** 19 Feb 09

TIME	CHAMBER AMBIENT	CHAMBER % R/H			REMARKS	TECH
1430	86.0	95.0				JP
1830	86.0	95.0				JP
2230	86.0	95.0				JP
0230	86.0	95.0				JP
0630	86.0	95.0				JP
0915	86.2	94.8			End Pre Soak	JP

Engineer

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC. Founded 1950

Job Number: 410742-00-000 Test: Fungus Date: 20 Feb 09

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
0930	0	86	85.6	90 - 99	95.7		JP
1330	4	|	83.1	|	94.9		JP
1730	8	|	86.4	|	94.3		VD
2130	12	|	85.6	|	94.4		VD
0130	16	|	85.8	|	94.7		HE
0530	20	|	85.8	|	94.3		HE
0930	24	86	85.8	90-99	94.7	Cycle 1 of 28	MK
0930	0	86	85.8	90 - 99	94.7		MK
1330	4	|	86.0	|	95.0		MK
1730	8	|	86.4	|	95.8		[illegible]
2130	12	|	86.2	|	95.4		[illegible]
0130	16	|	86.4	|	96.1		[illegible]
0530	20	|	86.2	|	95.7		[illegible]
0930	24	86	85.6	90-99	94.5	Cycle 2 of 28	VD
0930	0	86	85.6	90 - 99	94.5		VD
1330	4	|	86.0	|	94.2		VD
1730	8	|	86.6	|	95.0	*	[illegible]
2130	12	|	86.6	|	95.0	*	[illegible]
0130	16	|	86.6	|	94.9		[illegible]
0530	20	|	85.8	|	94.6		[illegible]
0930	24	86	86.2	90-99	95.5	Cycle 3 of 28	[illegible]
0930	0	86	86.2	90 - 99	95.5		[illegible]
1330	4	|	85.8	|	94.5		[illegible]
1730	8	|	85.8	|	94.6		SM
2130	12	|	86.0	|	95.7		VD
0130	16	|	85.8	|	95.0		[illegible]
0530	20	|	85.8	|	94.7		[illegible]
0930	24	86	86.6	90-99	95.2	Cycle 4 of 28	[illegible]

* Readings off chart recorder

Engineer [signature]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Job Number: 410742-00-000 Test: Fungus Date: 24 FEB 09

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
0930	0	86	86.6	90 - 99	95.2		mm
1330	4	|	86.0	|	95.0		MK
1730	8	|	85.8	|	94.1		VD
2130	12	|	86.2	|	95.1		VD
0130	16	|	86.0	|	95.1		[illegible]
0530	20	|	86.0	|	94.6		[illegible]
0930	24	86	85.8	90-99	94.5	Cycle 5 of 28	mm
0930	0	86	85.8	90 - 99	94.5		mm
1330	4	|	86.0	|	94.5		mm
1730	8	|	85.6	|	94.5		VD
2130	12	|	85.8	|	94.4		VD
0130	16	|	85.3	|	94.3		[illegible]
0530	20	|	85.8	|	94.4		[illegible]
0930	24	86	86.2	90-99	95.0	Cycle 6 of 28	mm
0930	0	86	86.2	90 - 99	95.0		mm
1330	4	|	86.2	|	95.5		mm
1730	8	|	86.0	|	95.0		mm
2130	12	|	86.2	|	95.9		VD
0130	16	|	86.4	|	95.6		[illegible]
0530	20	|	86.0	|	94.9		[illegible]
0930	24	86	85.6	90-99	94.3	Fungus ck ok JP Cycle 7 of 28	mm
0930	0	86	85.6	90 - 99	94.3		mm
1330	4	|	86.2	|	95.1		mm
1730	8	|	86.4	|	96.0		VD
2130	12	|	86.2	|	95.6		VD
0130	16	|	85.8	|	94.6		mm
0530	20	|	85.6	|	94.3		mm
0930	24	86	86.4	90-99	95.9	Cycle 8 of 28	JP

Engineer [signature]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 4 of 8

Job Number: 410742-00-000 Test: Fungus Date: 28 Feb 09

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
0930	0	86	86.4	90 - 99	95.9		JP
1330	4	|	86.4	|	95.6		JP
1730	8	|	86.0	|	94.5		[illegible]
2130	12	|	86.0	|	95.0		[illegible]
0130	16	|	86.2	|	95.8		[illegible]
0530	20	|	86.4	|	95.8		[illegible]
0930	24	86	86.2	90-99	95.3	Cycle 9 of 28	JP
0930	0	86	86.2	90 - 99	95.3		JP
1330	4	|	85.6	|	94.4		JP
1730	8	|	86.2	|	95.0		VD
2130	12	|	86.0	|	95.1		VD
0130	16	|	85.8	|	95.3		[illegible]
0530	20	|	86.2	|	95.4		[illegible]
0930	24	86	85.8	90-99	94.2	Cycle 10 of 28	[illegible]
0930	0	86	85.8	90 - 99	94.2		[illegible]
1330	4	|	85.6	|	94.2		[illegible]
1730	8	|	85.6	|	94.5		VD
2130	12	|	85.8	|	94.3		VD
0130	16	|	85.8	|	95.0		[illegible]
0530	20	|	86.0	|	95.3		[illegible]
0930	24	86	86.0	90-99	95.4	Cycle 11 of 28	MK
0930	0	86	86.0	90 - 99	95.4		MK
1330	4	|	86.2	|	95.5		MK
1730	8	|	85.6	|	94.6		JP
2130	12	|	85.8	|	94.4		VD
0130	16	|	85.8	|	95.2		[illegible]
0530	20	|	86.2	|	95.4		[illegible]
0930	24	86	85.8	90-99	95.2	Cycle 12 of 28	MK

Engineer [illegible]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC. Founded 1950

Job Number: 410742-00-000 Test: Fungus Date: 4 MAR 09

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
0930	0	86	85.8	90 - 99	95.2		MK
1330	4	|	86.2	|	95.4		MK
1730	8	|	86.4	|	95.7		mm
2130	12	|	86.0	|	94.7		[illegible]
0130	16	|	86.4	|	95.7		[illegible]
0530	20	|	86.0	|	95.3		[illegible]
0930	24	86	86.4	90-99	96.1	Cycle 13 of 28	[illegible]
0930	0	86	86.4	90 - 99	96.1		[illegible]
1330	4	|	86.0	|	95.5		[illegible]
1730	8	|	85.6	|	94.2		VD
2130	12	|	85.8	|	94.6		VD
0130	16	|	85.8	|	93.9		[illegible]
0530	20	|	86.0	|	95.3		[illegible]
0930	24	86	85.8	90-99	94.4	Cycle 14 of 28	mm
0930	0	86	85.8	90 - 99	94.4		mm
1330	4	|	86.0	|	95.4		mm
1730	8	|	85.8	|	94.6		VD
2130	12	|	85.8	|	94.5		VD
0130	16	|	86.2	|	95.1		HE
0530	20	|	86.0	|	95.5		HE
0930	24	86	85.8	90-99	95.4	Cycle 15 of 28	MK
0930	0	86	85.8	90 - 99	95.4		MK
1330	4	|	86.0	|	95.3		MK
1730	8	|	85.6	|	94.2		MK
2130	12	|	85.8	|	94.5		VD
0130	16	|	86.5	|	96.2		[illegible]
0630	20	|	86.0	|	95.0	CLOCKS AHEAD 1 HR DAYLIGHT SAVINGS TIME	[illegible]
1030	24	86	86.0	90-99	95.2	Cycle 16 of 28	[illegible]

Engineer [signature]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 6 of 8

Job Number: 410742-00-000 Test: Fungus Date: 8 March 04

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
1030	0	86	86.0	90 - 99	95.2		
1430	4	|	85.6	|	94.3		VD
1830	8	|	85.6	|	94.0		VD
2230	12	|	85.5	|	93.9		VD
0230	16	|	85.8	|	94.5		[illegible]
0630	20	|	85.6	|	94.2		[illegible]
1030	24	86	85.8	90-99	94.6	Cycle 17 of 28	SM
1030	0	86	85.8	90 - 99	94.6		SM
1430	4	|	85.8	|	94.2		SM
1830	8	|	86.2	|	95.8		VD
2230	12	|	86.2	|	95.4		VD
0230	16	|	86.1	|	95.2		[illegible]
0630	20	|	85.8	|	94.1		[illegible]
1030	24	86	86.4	90-99	96.0	Cycle 18 of 28	SM
1030	0	86	86.4	90 - 99	96.0		SM
1430	4	|	86.0	|	95.9		VD
1830	8	|	86.4	|	94.8		VD
2230	12	|	85.8	|	94.7		VD
0230	16	|	85.6	|	94.1		[illegible]
0630	20	|	86.2	|	94.5		[illegible]
1030	24	86	85.6	90-99	94.3	Cycle 19 of 28	[illegible]
1030	0	86	85.6	90 - 99	94.3		[illegible]
1430	4	|	86.0	|	94.7		SM
1830	8	|	86.4	|	95.9		VD
2030	12	|	86.4	|	95.9		VD
0230	16	|	86.0	|	95.0		[illegible]
0630	20	|	86.0	|	94.9		[illegible]
1030	24	86	86.1	90-99	94.6	Cycle 20 of 28	[illegible]

Engineer [signature]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 7 of 8

Job Number: 410742-00-000 Test: Fungus Date: 12 MAR 09

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
1030	0	86	86.1	90 - 99	94.6		mm
1430	4	|	85.6	|	94.0		mm
1830	8	|	85.8	|	94.9		VD
2230	12	|	86.4	|	95.9		VD
0230	16	|	85.8	|	94.2		
0630	20	|	86.4	|	95.6		
1030	24	86	85.6	90-99	94.7	Cycle 21 of 28	MK
1030	0	86	85.6	90 - 99	94.7		MK
1430	4	|	85.8	|	94.9	* READING OFF CHART	VD
1830	8	|	86.2	|	95.9		VD
2230	12	|	86.0	|	95.2		
0230	16	|	85.6	|	94.2		HE
0630	20	|	85.8	|	94.9		JP
1030	24	86	86.0	90-99	94.9	Cycle 22 of 28	JP
1030	0	86	86.0	90 - 99	94.9		JP
1430	4	|	85.8	|	94.5		JP
1830	8	|	86.2	|	94.7		VD
2230	12	|	86.0	|	95.0		VD
0230	16	|	85.8	|	94.8		
0630	20	|	86.2	|	95.8		
1030	24	86	86.0	90-99	94.8	Cycle 23 of 28	mm
1030	0	86	86.0	90 - 99	94.8		mm
1430	4	|	85.8	|	94.6		mm
1830	8	|	86.5	|	96.0		JP
2230	12	|	85.6	|	94.1		JP
0230	16	|	85.6	|	94.1		
0630	20	|	85.6	|	94.4		
1030	24	86	86.0	90-99	98.2	Cycle 24 of 28	mm

Engineer [signature]

ALL TEMPERATURE IN DEGREES F

DAYTON T. BROWN INC.
Founded 1950

Page 8 of 8

Job Number: 410742-00-000 Test: Fungus Date: 16 Mar 09

TIME	TEST TIME HOURS	REQ CHAM TEMP	ACTUAL CHAM TEMP	REQ CHAM % RH	ACTUAL CHAM % RH	REMARKS	TECH
1030	0	86	86.0	90 - 99	95.2		mm
1430	4	|	85.6	|	94.4		mm
1830	8	|	86.0	|	94.8		VD
2230	12	|	86.0	|	95.1		VD
0230	16	|	85.8	|	94.0		[illegible]
0630	20	|	85.6	|	94.0		[illegible]
1030	24	86	85.6	90-99	94.1	Cycle 25 of 28	MK
1030	0	86	85.6	90 - 99	94.1		MK
1430	4	|	85.9	|	95.2		MK
1830	8	|	86.2	|	94.7		VD
2230	12	|	85.6	|	94.4		VD
0230	16	|	85.6	|	94.8		[illegible]
0630	20	|	86.0	|	95.1		[illegible]
1030	24	86	86.2	90-99	95.9	Cycle 26 of 28	mm
1030	0	86	86.2	90 - 99	95.9		mm
1430	4	|	86.2	|	94.8		mm
1830	8	|	86.4	|	95.9		VD
2230	12	|	86.4	|	95.8		VD
0230	16	|	86.0	|	95.0		[illegible]
0630	20	|	85.6	|	94.1		[illegible]
1030	24	86	85.6	90-99	94.0	Cycle 27 of 28	mm
1030	0	86	85.6	90 - 99	94.0		mm
1430	4	|	85.8	|	94.6		mm
1830	8	|	86.2	|	95.5		VD
2230	12	|	85.6	|	94.1		VD
0230	16	|	85.6	|	94.4		[illegible]
0630	20	|	86.4	|	95.1		[illegible]
1030	24	86	86.0	90-99	94.6	Cycle 28 of 28	[illegible]

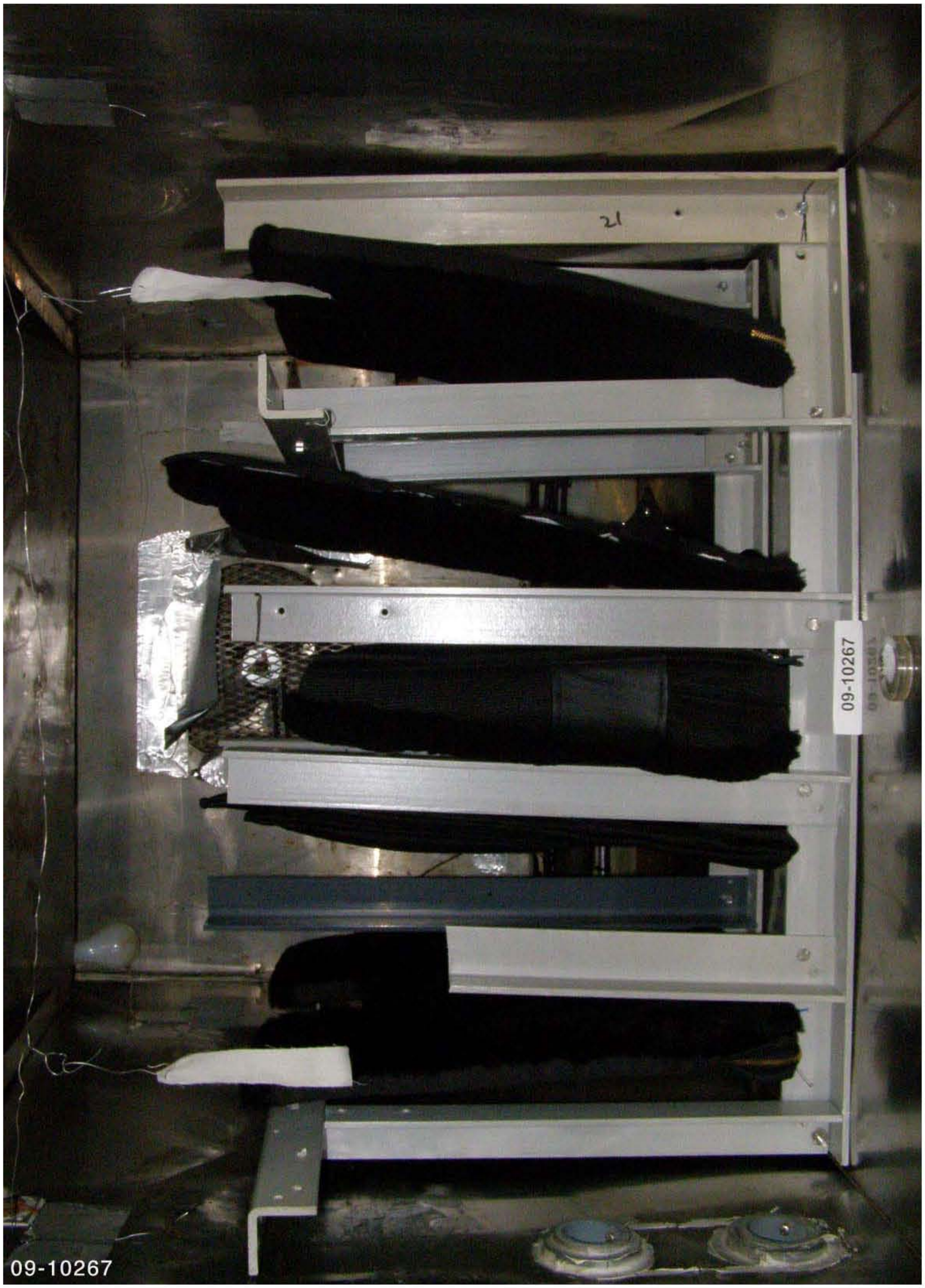
Engineer [signature]

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

Job Sub: 410742-00 **TEST: FUNGUS**

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
ATL II	A.T.L.	N/A	04E-015	N/A	N.C.R.
RECORDER, CHART TRULINE	HONEYWELL	DR4500	12-9	RTD ± 0.5°F, RH ± 0.2% RH	12/06/2009
CONTROLLER, ENVIRONMENTAL SYSTEM	JC SYSTEMS	600A-RTD	25-160	RTD ± 1.08°F RH ± 1% RH	06/14/2009
TRANSMITTER, HUMIDITY AND TEMPERATURE	VAISALA	HMP235	31-30	± 2%(3-96 % RH) ± 0.36°F	11/01/2009

09-0623 Enc 8 Pg 10



TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
TYPICAL VIEW OF THE TEST ITEMS SETUP FOR THE FUNGUS TEST
JOB NO. 410742-00-000 FILE NO. 09-10267 12 FEBRUARY 2009
DTB04R09-0623 ENCLOSURE 8 PHOTO 1

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
CLOSE-UP POST-FUNGUS TEST VIEW OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-0861 20 MARCH 2009
DTB04R09-0623 ENCLOSURE 8 PHOTO 2

DAYTON T. BROWN INC.
Founded 1950

09-0862

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
CLOSE-UP POST-FUNGUS TEST VIEW OF ONE OF THE TEST ITEMS

JOB NO. 410742-00-000	FILE NO. 09-0862	20 MARCH 2009
DTB04R09-0623	ENCLOSURE 8	PHOTO 3

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
CLOSE-UP POST-FUNGUS TEST VIEW OF ONE OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-0863 20 MARCH 2009
DTB04R09-0623 ENCLOSURE 8 PHOTO 4

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
CLOSE-UP POST-FUNGUS TEST VIEW OF ONE OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-0864 20 MARCH 2009
DTB04R09-0623 ENCLOSURE 8 PHOTO 5

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
CLOSE-UP POST-FUNGUS TEST VIEW OF ONE OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-0865 20 MARCH 2009
DTB04R09-0623 ENCLOSURE 8 PHOTO 6

DAYTON T. BROWN INC.
Founded 1950

TESTED FOR UNITED STATES AIR FORCE
ITEM: SEAT CUSHIONS
CLOSE-UP POST-FUNGUS TEST VIEW OF ONE OF THE TEST ITEMS
JOB NO. 410742-00-000 FILE NO. 09-0866 20 MARCH 2009
DTB04R09-0623 ENCLOSURE 8 PHOTO 7

DAYTON T. BROWN INC.
Founded 1950

Enclosure 9

Explosive Decompression Test and Results

09-0623

TEST REQUIREMENT

The explosive decompression test shall be conducted in accordance with references (d), (e), and (f) and as directed by S. Fleming (United States Air Force).

TEST RESULTS

The explosive decompression test was conducted on one Goodrich (Air Bladder) Seat Cushion.

A pretest visual inspection of the test item revealed no anomalies.

All testing was performed in accordance with the referenced specifications and as directed by S. Fleming (United States Air Force). Specifically, five rapid decompression events were conducted on the operating test item. The rapid decompression event consisted of the quickest pressure decrease from 8,000-foot altitude conditions to 40,000-foot altitude conditions that could be attained using a large valve and the Dayton T. Brown, Inc. rapid decompression tank. Additionally, during the rapid decompression events, the Seat Cushion deflection was measured using a linear voltage differential transducer (LVDT). Strip chart data of the Seat Cushion deflection during the rapid decompression events is not included in this report, but has been submitted separately to the United States Air Force, Wright Patterson AFB.

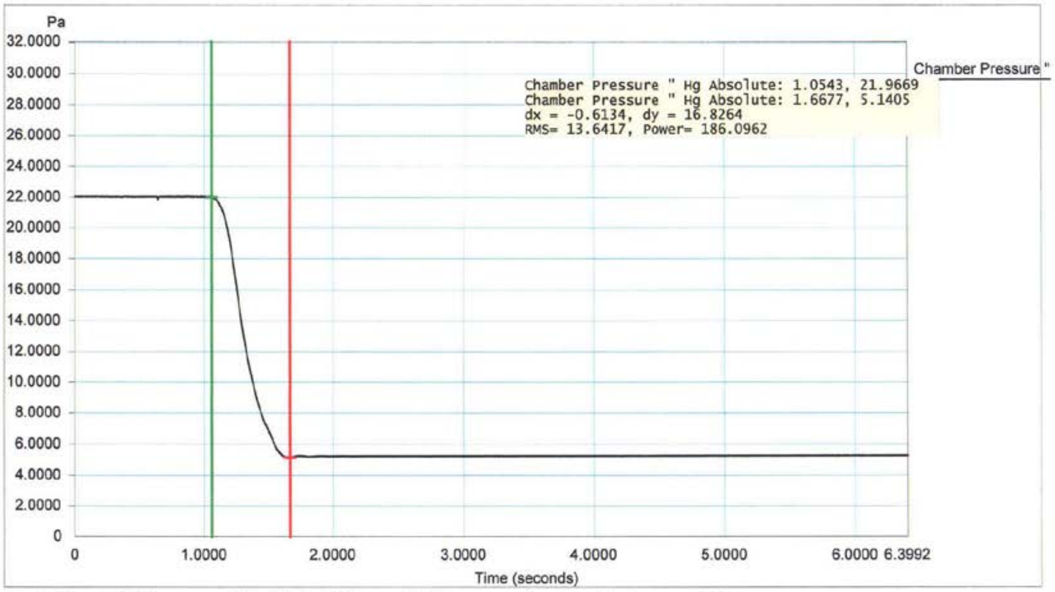
The test item was operated during the test.

Refer to the test data sheets on the following pages for the results of the explosive decompression test.

The test item completed all phases of testing. However, shortly after each rapid decompression event, the Seat Cushion deflection data revealed that the test item had stopped operating. As such, prior to the next rapid decompression event, the test item switch was cycled off and then on which resulted in the test item operating correctly.

A post-test visual inspection of the test item revealed no anomalies due to testing.

1,2009 05-46-34
Decompression Mar 11,2009 05-46-34
Project File Name: Decomp.prj-1
Test Type: Signal Analysis and Waveform Source   Run Folder: .\TempData Mar 11,2009 05-35-06



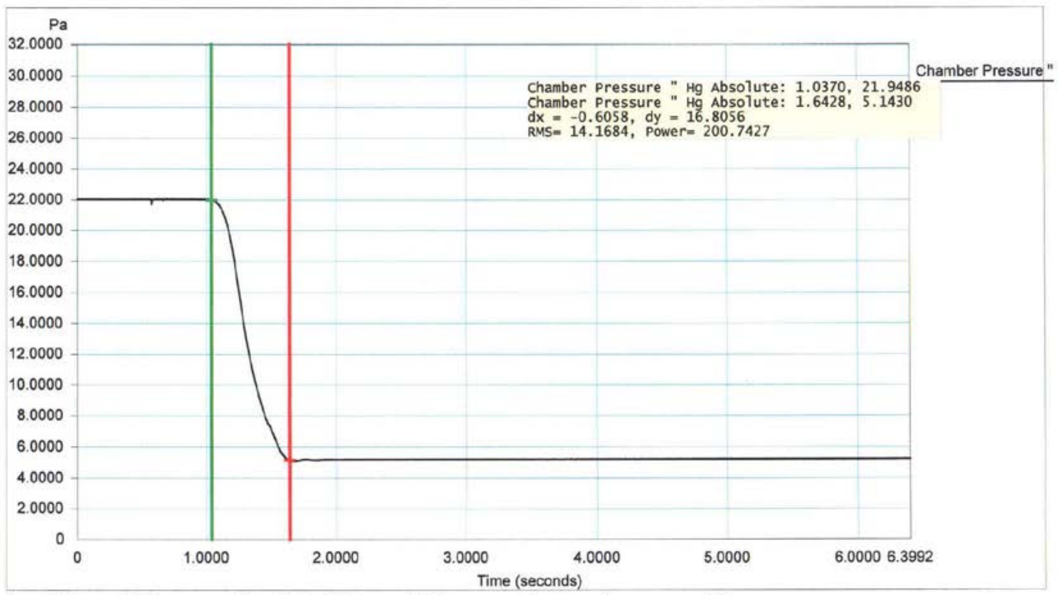
Spectral Lines: 3200   Time Capture Points: 8192   Frequency Span: 500
Average Type: None
Frame Number: 1   Window Type: None

Data saved at 05:46:35 AM, Wednesday, March 11, 2009   Report created at 05:46:37 AM, Wednesday, March 11, 2009

09-0623 Enc 9 Pg 2

09-0623 Enc 9 Pg 3

Mar 11,2009 06-41-08
Decompression Mar 11,2009 06-41-08
Project File Name: Decomp.prj-2
Test Type: Signal Analysis and Waveform Source Run Folder: .\TempData Mar 11,2009 06-32-34

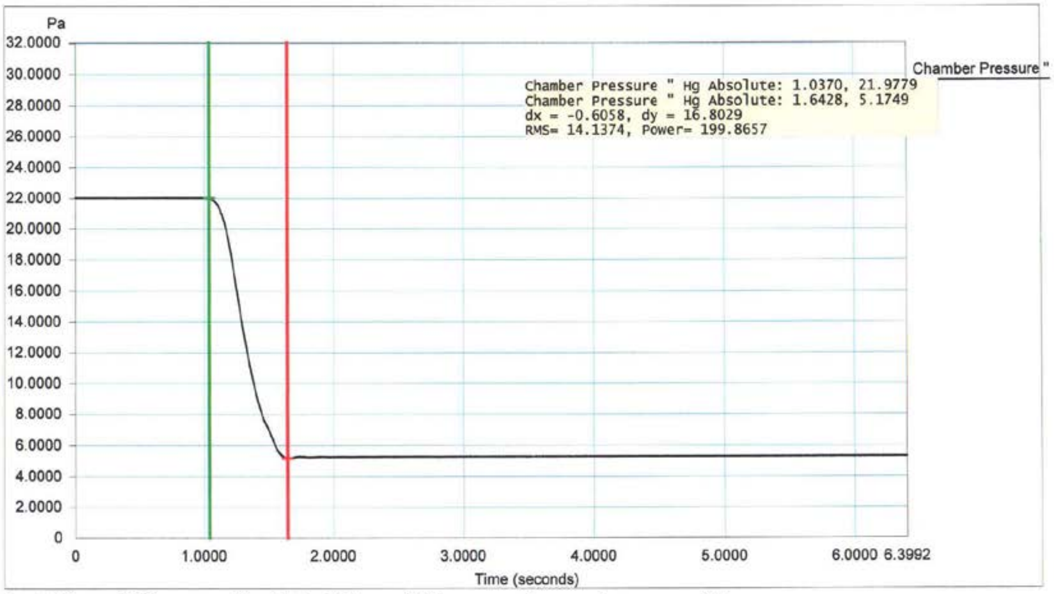


Spectral Lines: 3200 Time Capture Points: 8192 Frequency Span: 500
Average Type: None
Frame Number: 1 Window Type: None

Data saved at 06:41:08 AM, Wednesday, March 11, 2009 Report created at 06:41:10 AM, Wednesday, March 11, 2009

192

Mar 11,2009 07-41-31
Decompression Mar 11,2009 07-41-31
Project File Name: Decomp.prj -3
Test Type: Signal Analysis and Waveform Source Run Folder: .\TempData Mar 11,2009 07-36-38



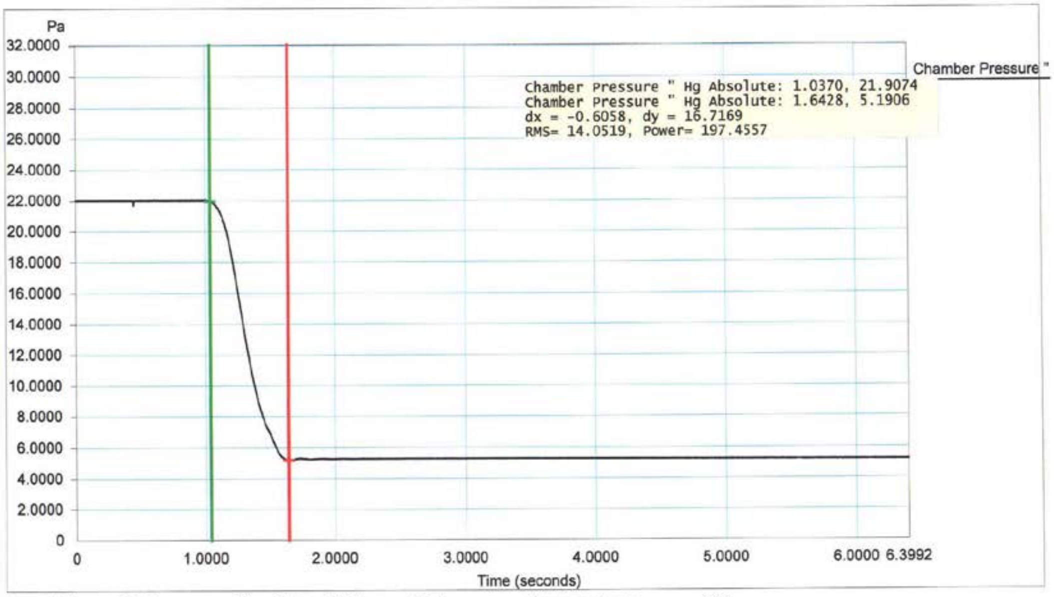
Spectral Lines: 3200 Time Capture Points: 8192 Frequency Span: 500
Average Type: None
Frame Number: 1 Window Type: None

Data saved at 07:41:31 AM, Wednesday, March 11, 2009 Report created at 07:41:33 AM, Wednesday, March 11, 2009

09-0623 Enc 9 Pg 4

1P3

Mar 11,2009 08-33-09
Decompression Mar 11,2009 08-33-09
Project File Name: Decomp.prj-4
Test Type: Signal Analysis and Waveform Source
Run Folder: .\TempData Mar 11,2009 08-26-29



Spectral Lines: 3200 Time Capture Points: 8192 Frequency Span: 500
Average Type: None
Frame Number: 1 Window Type: None

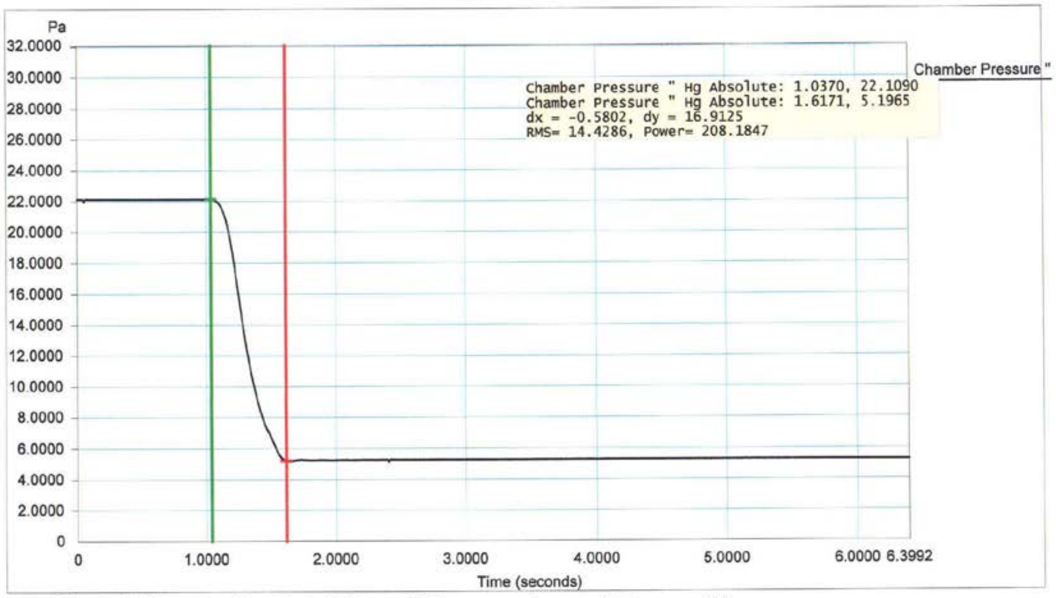
Data saved at 08:33:09 AM, Wednesday, March 11, 2009 Report created at 08:33:11 AM, Wednesday, March 11, 2009

09-0623 Enc 9 Pg 5

184

Mar 11,2009 09-44-06
Decompression Mar 11,2009 09-44-06

Project File Name:	Decomp.prj-5		
Test Type:	Signal Analysis and Waveform Source	Run Folder:	.\TempData Mar 11,2009 09-32-56



Spectral Lines:	3200	Time Capture Points:	8192	Frequency Span:	500
Average Type:	None				
Frame Number:	1	Window Type:	None		

Data saved at 09:44:06 AM, Wednesday, March 11, 2009 Report created at 09:44:09 AM, Wednesday, March 11, 2009

09-0623 Enc 9 Pg 6

IA5

Test equipment utilized for the program reported herein was within its assigned interval of calibration.
Details are on file at Dayton T. Brown, Inc. and will be made available upon request.

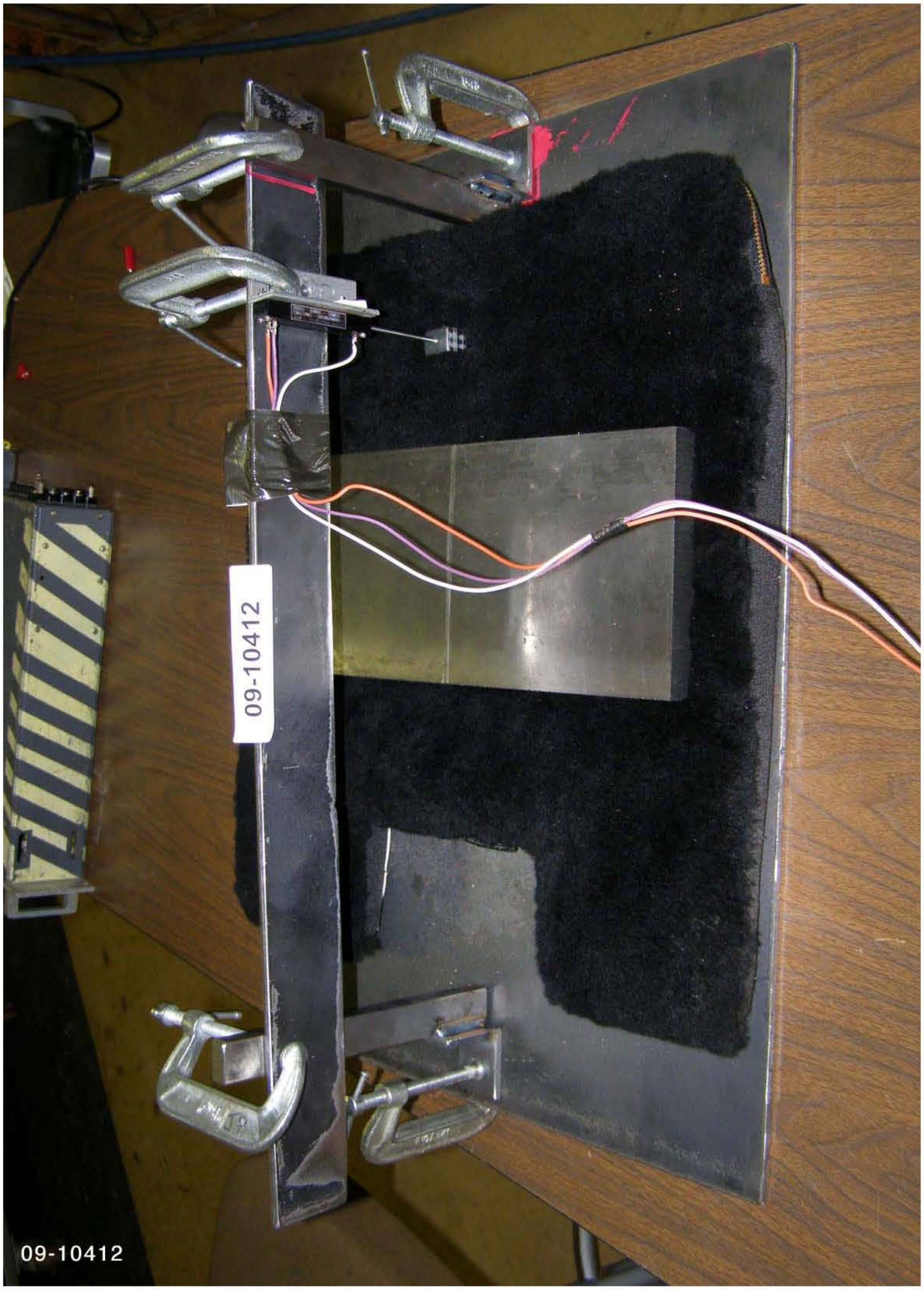
Job Sub: **410742-00** **TEST: EXPLOSIVE DECOMPRESSION**

09-0623 Enc 9 Pg 7

ITEM	MANUFACTURER	MODEL	DTB NO.	ACCURACY	CAL DUE DATE
CHAMBER, 20 FT TEMPERATURE/ALTITUDE	ATMOSPHERE UNLIMITED	20 FT	04E-008	N/A	N.C.R.
DYNAMIC SIGNAL ANALYSIS SYSTEM	DACTRON	PHOTON	10-176	MFR	12/06/2009
RECORDING SYSTEM, PORTABLE	GOULD	TA11	12-16	MFR	11/15/2009
LINEAR POT, 5K OHMS	ETI	LCP12B-50	17-10	± 0.7 FS	03/07/2010
CONTROLLER, ENVIRONMENTAL SYSTEM	JC SYSTEMS	600-RTD	25-136	RTD ± 1.08°F, ± 1% + 1 DIG. "HG	08/23/2009
POWER SUPPLY, DC	HEWLETT-PACKARD	6443B	36-75	MFR	02/06/2011
MANOMETER, 31" HG	UEHLING	30	40-1	± 1% F/S	09/13/2009
TRANSDUCER, PRESSURE 0 - 32 IN HG	HEISE	HPO	40-27	± 0.3% OF FULL SCALE	04/26/2009
TRANSDUCER, PRESSURE	HEISE	HPO	40-31	± 0.3% OF FS	04/26/2009
MANOMETER, 31" HG	UEHLING	30	40-80	0.5% FS	11/08/2009
MULTIMETER, TRUE RMS	FLUKE	87 SERIES V	9-171	MFR	09/13/2009

TESTED FOR UNITED STATES AIR FORCE
ITEM: GOODRICH (AIR BLADDER) SEAT CUSHION
TYPICAL VIEW OF THE TEST ITEM SETUP FOR THE EXPLOSIVE DECOMPRESSION TEST
JOB NO. 410742-00-000 FILE NO. 09-10411 11 MARCH 2009
DTB04R09-0623 ENCLOSURE 9 PHOTO 1

DAYTON T. BROWN INC.
Founded 1950



TESTED FOR UNITED STATES AIR FORCE
ITEM: GOODRICH (AIR BLADDER) SEAT CUSHION
TYPICAL VIEW OF THE TEST FIXTURE AND LVDT SETUP FOR MEASURING THE SEAT CUSHION DEFLECTION DURING THE EXPLOSIVE DECOMPRESSION TEST

JOB NO. 410742-00-000 FILE NO. 09-10412 11 MARCH 2009
DTB04R09-0623 ENCLOSURE 9 PHOTO 2

DAYTON T. BROWN INC.
Founded 1950

APPENDIX F: EMI Results

ENGINEERING AND TEST DIVISION
1195 CHURCH STREET, BOHEMIA, LONG ISLAND, NEW YORK 11716 (631) 589-6300

TEST REPORT NO.: 410741-00-01-R09-0012

DAYTON T. BROWN, INC. JOB NO.: 410741-00-000

CUSTOMER: INFOSCITEX CORPORATION
303 BEAR HILL CORPORATION
WALTHAM, MA 02451

SUBJECT: EMISSIONS AND SUSCEPTIBLITY TESTING ON A B2 SEAT CUSHION, PART NO. 31218-BA2106-1

PURCHASE ORDER NO.: 10866

ATTENTION: SCOTT FLEMING

THIS REPORT CONTAINS: 60 PAGES

PREPARED BY:	M. White MICHELLE WHITE
TEST ENGINEER:	Stephen Delurey
DEPARTMENT SUPERVISOR:	Keith Cummings
QUALITY DEPARTMENT:	S. Mi
DATE:	06/02/2009

THE DATA CONTAINED IN THIS REPORT WAS OBTAINED BY TESTING IN COMPLIANCE WITH THE APPLICABLE TEST SPECIFICATION AS NOTED

Revision History

Revision	Date	Section Affected	Change
-	Original Release	-	

Table of Contents

List of Figures

List of Tables

1.0 Abstract

This report details the results of the electromagnetic emissions and susceptibility test program on the B2 Seat Cushion. Testing was performed in accordance with MIL-STD-461E and was performed at Dayton T. Brown, Inc., Bohemia, New York.

The B2 Seat Cushion, hereafter is referred to as EUT (Equipment Under Test).

The part number(s), model number(s), and serial number(s) of the EUT components are as follows:

EUT Components

Component	Part No.	Model No.	Serial No.
B2 Seat Cushion	31218-BA2106-1	Not applicable	EMI

The EUT enclosure dimensions are as follows:

EUT Dimensions

Component	Width (inches)	Height (inches)	Depth (inches)	Weight (lbs)
B2 Seat Cushion	18	25	2	Approx. 4

Pre and post-test inspections revealed no external physical damage.

1.1 Test Summary

The table below lists the tests performed and the corresponding test results:

Test Summary

Test Method	Description	MIL-STD-461E Limit	Met Spec. Yes	Met Spec. No
RE102	Radiated Emissions, Electric Field, 10 kHz to 18 GHz	Figure RE102-3	X	
RS103	Radiated Susceptibility, Electric Field, 2 MHz to 18 GHz	Level of 60 V/m	X	
AATCC76	Surface Resistivity Testing	Between 1 Meg and 10 Mohm per sq. in. @ 72º/12% rh		X*

*Although not stated by the sub-contracted test laboratory (ETS) the reading on the EUT appears to exceed the upper limit (i.e. > 10 Mohm/sq. in.).

The test results recorded in this report relate only to those items tested.

The test data pertinent to this program will remain on file at Dayton T. Brown, Inc. for 90 days.

This report shall not be reproduced, except in full, without the written approval of Dayton T. Brown, Inc.

2.0 References

References

a)	AFRL/HEPA 0001 System Requirements Document (SRD) Seat Cushion, dated September 2006.
b)	MIL-STD-461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 20 August 1999.

3.0 Administrative Information

Administrative Information

a)	Quantity Received:	One
b)	Date(s) Tested:	January 29 through February 2, 2009
c)	Date Shipped:	Retained at DTB for further testing
d)	No Customer representatives were present during testing.	

4.0 Test Sample Information

4.1 Description of Test Sample

The EUT is used in a B2 Bomber Aircraft.

4.2 Modifications

No modifications were made to the EUT during the course of this testing program.

4.3 Power Required

During testing, the input power was periodically monitored and maintained for the below condition:

(4) 1.2 VDC Nicad rechargeable Batteries

5.0 Test Sample Operation

5.1 Mode of Operation

All testing was performed with the EUT operating as follows:

The Air Pump was continuously operating on battery power.

5.2 Susceptibility Criteria

During susceptibility testing, operation of the EUT was monitored for any indication of malfunction or degradation of operation. Operation of the EUT was monitored by Dayton T. Brown, Inc. personnel during the susceptibility testing.

The output of the Air Pump was monitored by an electronic pressure gauge. Any change in pre-test pressure reading was considered a failure.

6.0 General Test Information

6.1 Test Facility

All testing was performed at Dayton T. Brown, Inc., Bohemia, New York.

6.2 Test Chamber

The electromagnetic emissions and susceptibility tests described in this report were conducted in a shielded enclosure, capable of attenuating signals 100 dB over the spectrum of 10 kHz to 10 GHz. The enclosure was suitably bonded to earth ground via a single point ground.

During all testing, any peripheral equipment utilized was located in a solid type auxiliary anteroom. Access from the anteroom to the main enclosure was made via a bulkhead mounted between the two enclosures.

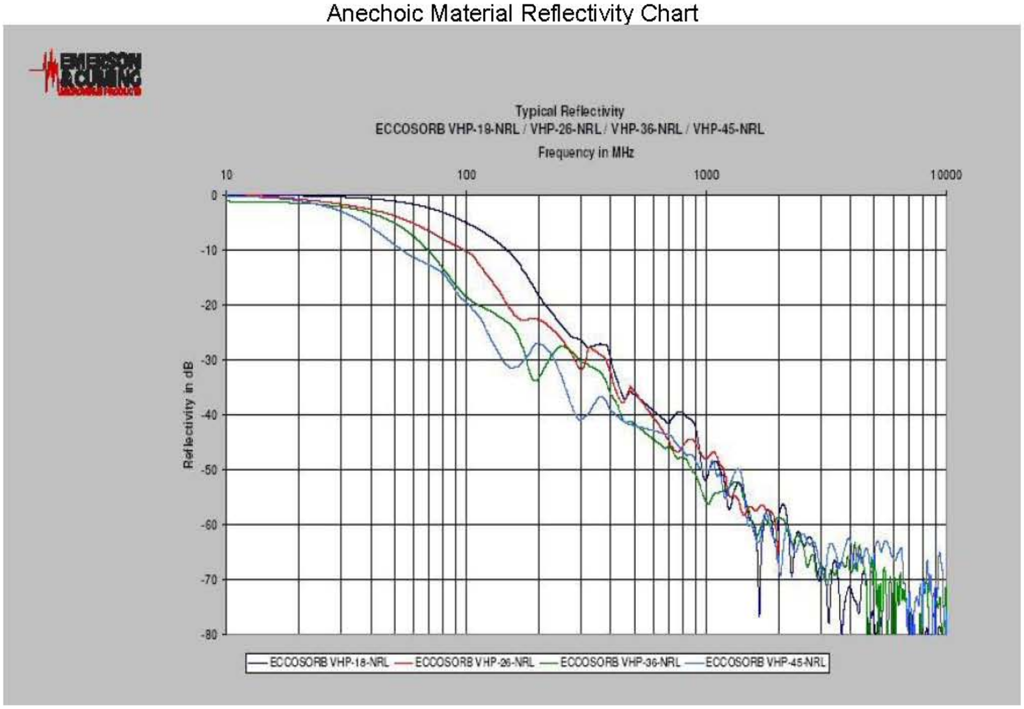
All lines carrying power into the shielded enclosures were passed through RF suppression filters suitably bonded to the enclosures and capable of 100 dB attenuation over a spectrum of 10 kHz to 10 GHz.

The anechoic material lining the test enclosure is ECCOSORB VHP-26-NRL and is manufactured by Emerson & Cummings Microwave Products. Detailed absorption characteristics are shown in the following table and figure. The Anechoic material is placed above, behind and on both sides of the test setup boundary. The test setup boundary is spaced at least 30 cm from the absorption material located behind and to its sides. The absorption material located above the setup boundary and to its sides extend from the wall behind the boundary to a point at least 50 cm beyond the front of the setup boundary, see the absorber placement figure.

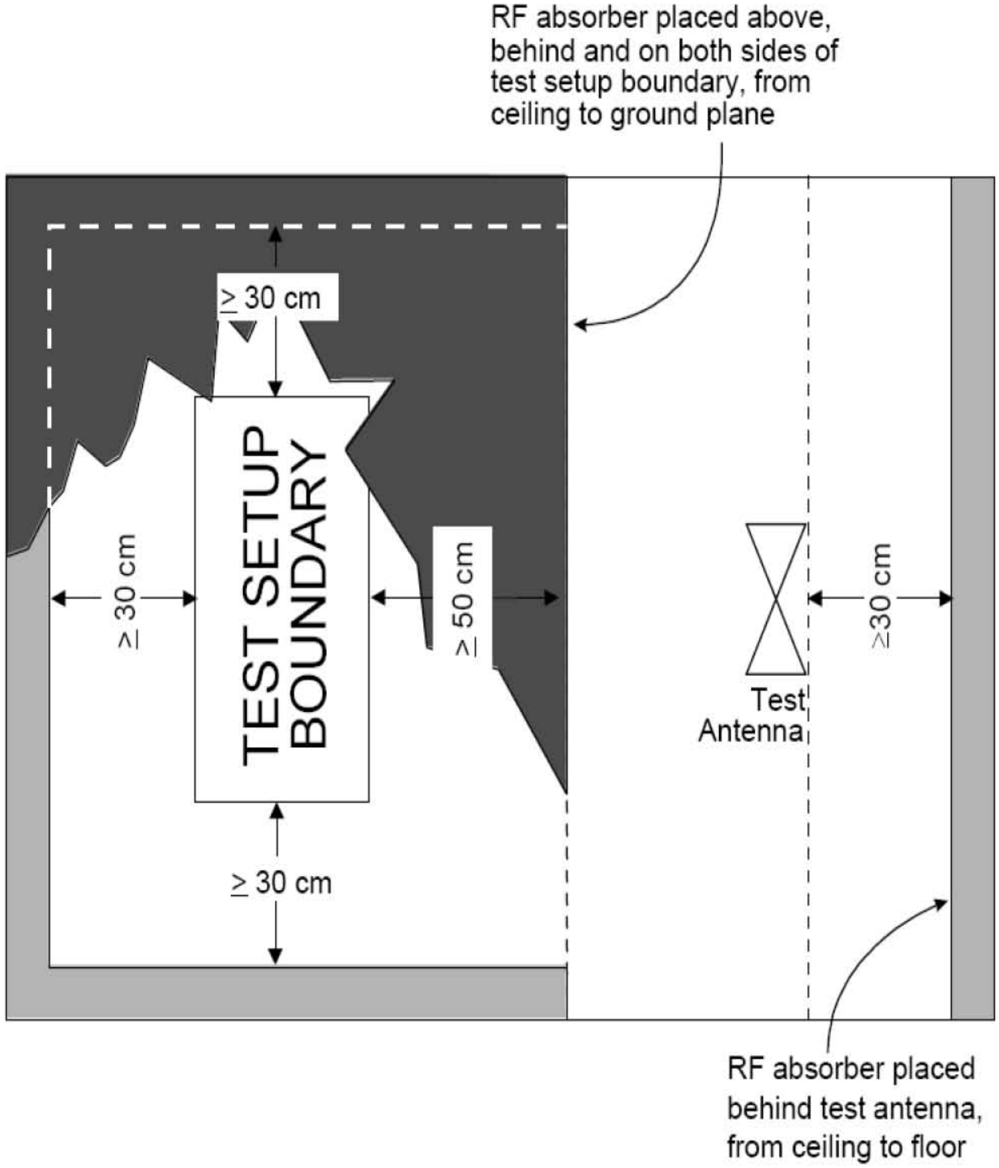
Anechoic Material Reflectivity Table

GUARANTEED MAXIMUM REFLECTIVITY OF ECCOSORB® VHP GRADES										
	120 MHz	200 MHz	300 MHz	500 MHz	1 GHz	3 GHz	5 GHz	10 GHz	15 GHz	24 GHz
VHP-2-NRL							-30	-40	-45	-50
VHP-4-NRL						-30	-40	-45	-50	-50
VHP-8-NRL					-30	-40	-50	-50	-50	-50
VHP-12-NRL				-25	-35	-40	-50	-50	-50	-50
VHP-18-NRL				-30	-40	-45	-50	-50	-50	-50
VHP-26-NRL			-25	-35	-40	-50	-50	-50	-50	-50
VHP-36-NRL		-20	-30	-35	-45	-50	-50	-50	-50	-50
VHP-45-NRL	-20	-25	-35	-40	-45	-50	-50	-50	-50	-50

Anechoic Material Reflectivity Chart



Anechoic Material Placement



6.3 Ambient Profile

During the course of emissions measurements, if all levels observed were below the specification limits by at least 6 dB, ambient measurements were not performed. If the EUT failed an emissions test requirement, ambient measurements were performed and ambient measurement data was recorded and included in this test report.

6.4 Setup

All testing was performed within a shielded enclosure.

The EUT was mounted on a copper ground plane in accordance with Figure 2 of MIL-STD-461E. The ground plane had a conductivity of less than 0.1 milliohms per square inch and covered an area of at least 2.25 square meters, with its smaller side having a dimension of no less than 76 cm. The bench top ground plane utilized was copper, 1mm thick measuring 3.05m long by 1.22m deep.

The EUT was located on the ground plane 10 ± 2 cm from the front edge with the prime radiating face, or front of the EUT facing the antenna.

The prime radiating face, or the front of the EUT, faced the antenna.

The DC bonding resistance of the ground plane to the shielded enclosure were measured and recorded.

All monitoring and support equipment was located in a shielded anteroom located adjacent to the test enclosure. The two enclosures were joined by a common wall-mounted bulkhead through which the EUT signal interface and test instrumentation lines passed.

Photographs of the test setups are included in each test method.

7.0 Test Instrumentation

7.1 Instrumentation Characteristics

The test equipment utilized for this test program was calibrated to the requirements of ANSI/NCSL Z540-1 and ISO/IEC 17025 using standards traceable to the National Institute of Standards and Technology. The test equipment was within its assigned interval of calibration. Details are on file at Dayton T. Brown, Inc., and will be made available upon request.

7.2 Emissions Testing

A computerized interference measurement system was utilized to measure and plot emissions that were detected during the tests in the frequency range of 10 kHz to 18 GHz.

Prior to testing, the computer was programmed with the appropriate antenna factor, and any cable losses. At each frequency measured, the computer added the appropriate correction factors to the measured data. The data is presented on amplitude versus frequency plot(s). The applicable specification limit is displayed on the plot(s). All pertinent information on the test is listed on the data plot(s). Computer software programs and version numbers are identified in the individual test methods. The peak detector function was utilized for all measurements.

For all emission measurements, the following bandwidths and measurement times were utilized:

Bandwidths and Measurement Times

Frequency Range	6 dB Bandwidth	Dwell Time
10 to 150 kHz	1 kHz	0.02 Sec
150 kHz to 30 MHz	10 kHz	0.02 Sec
30 MHz to 1 GHz	100 kHz	0.02 Sec
1 to 18 GHz	1 MHz	0.02 Sec

Synthesized measurement receivers were stepped in one-half bandwidth increments.

Video filtering was not used to bandwidth limit the receiver response. If a controlled video bandwidth was available on the measurement receiver, it was set to its greatest value.

During emissions testing, the EMI receiver was powered through an isolation transformer and its chassis was grounded at a single point. When pre-amps were utilized they were also powered through an audio isolation transformer and were connected at a single point to the grounded chassis of the EMI receiver.

All emission calibration setups were as specified in MIL-STD-461E.

7.3 Susceptibility Testing

For all susceptibility tests, the following step sizes were utilized:

Susceptibility Scanning Step Sizes

	Stepped Scans
Frequency Range	Maximum Step Size
2 to 30 MHz	0.01 fo
30 MHz to 1 GHz	0.005 fo
1 GHz to 8 GHz	0.001 fo
8 to 18 GHz	0.0005 fo

(fo = tuned frequency)

For stepped scans, the dwell time at each frequency was a minimum of 3 seconds.

Susceptibility test signals for RS103 were pulse modulated with a 1 kHz square wave (50% duty cycle) signal.

All susceptibility calibration setups were as specified in MIL-STD-461E.

8.0 Test Methods

The following sections provide detailed test parameters and test results for each test method performed.

8.1 Radiated Emissions, Method RE102, Electric Field

8.1.1 Purpose

The purpose of this test is to verify that electric field emissions from the EUT and its associated cabling do not exceed the specified requirements.

8.1.2 Limit

MIL-STD-461E, Figure RE102-3, Aircraft and Space System Applications, Fixed Wing External.

8.1.3 Test Setup

The test setup was as detailed in Paragraph 6.4 of this document.

The interference analyzer and controlling computer were positioned in the ancillary enclosure. No part of any antenna was closer than 1 meter from the walls and 0.5 meter from the ceiling of the shielded enclosure. All antennas were located at a distance of 1 meter from the test setup boundary. All antennas except the 104 cm rod antenna were positioned 120 cm (measured from the center axis of the antenna) above the floor of the shielded enclosure. The 104 cm rod antenna matching network was electrically bonded and positioned at the same level as the ground plane.

The test setup employed was as detailed in the test setup photograph(s).

8.1.4 Equipment List

ITEM	MANUFACTURER	MODEL	DTB NO.	CAL DUE DATE
ANECHOIC CHAMBER, #1 20' X 20' X 12'	RAYPROOF	81	01E-026	No Calib Required
GENERATOR, AM/FM SIGNAL 9KHZ - 1.2 GHZ	IFR	2023A	24-22	11/08/2009
GENERATOR, SYNTHESIZED SWEEPER	AGILENT TECHNOLOGIES	83640B	24-29	01/03/2010
RADIATING STUB, 30 MHZ - 18 GHZ	ELECTRO-METRICS	EM-6888	27-2	08/29/2010
ANTENNA, BICONICAL	EMCO	3104	27-32	04/05/2009
ACTIVE MONOPOLE, 30 HZ - 50 MHZ	EMCO	3301B	27-36	10/24/2010
ANTENNA, DOUBLE RIDGED GUIDE	EMCO	3117	27-375	04/25/2010
ANTENNA, DOUBLE RIDGED GUIDE	EMCO	3106	27-42	05/24/2009
ANTENNA, ROD CALIBRATION FIXTURE	DAYTON T. BROWN	WT-2	27-52	11/08/2009
RECEIVER, TEST 20 HZ TO 40 GHZ	ROHDE & SCHWARZ	ESIB40	65-204	09/13/2009
CABLE, TEST	PASTERNACK	RG214/U	7-1	09/20/2009
PREAMPLIFIER, MICROWAVE 1 - 26.5 GHZ	HEWLETT-PACKARD	8449B	71-11	10/10/2010
AMPLIFIER, 10.0 KHZ - 1.0 GHZ APPROX. 50 dB	MITEQ	AM-1309	71-22	02/15/2009
CABLE, TEST 6 FT LONG TYPE N	PASTERNACK	RG214/U	7-155	09/27/2009
CABLE, TYPE N MALE TO MALE TEST	PASTERNACK	RG214/U	7-83	10/11/2009

8.1.4.1 Software

Software	Manufacturer	Version
TILE!	Quantum Change	3.4.K.29

8.1.5 Calibration

For the 104 cm rod antenna, the rod element was removed and an antenna matching network was connected in its place. A calibrated signal was applied to the antenna matching network, which was 6 dB below the MIL-STD-461E limit at 10.5 kHz, 100 kHz, 2 MHz, 10 MHz, and 29.5 MHz. A scan was performed in the same manner as a normal data scan and the data recorded was verified to be within ±3 dB of the injected level.

For the frequency range of 10 kHz to 18 GHz, a calibrated signal was applied to the coaxial cable at the antenna connection point, which was 6 dB below the MIL-STD-461E limit at 29.5 MHz, 195 MHz, 995 MHz, and 17.9 GHz. A scan was performed in the same manner as a normal data scan and the data recorded was verified to be within ±3 dB of the injected level. In addition, for the frequency range of 10 kHz to 1 GHz, a signal from a stub radiator was radiated into the receiving antenna at, 29.5 MHz, 195 MHz, 995 MHz, and 17.9 GHz and verified that a received signal was present.

Note: the calibration frequencies have been offset from the stop frequency of each antenna (30, 200, 1000 MHz, and 18 GHz) to assure that both side bands of the calibration signal are captured.

8.1.5.1 Calibration Calculations

Freq	Spec Limit	Spec Limit -6 dB	Antenna Factor	Cal Fixture Correction	Inject Level into Fixture	Inject Level into Cable
(MHz)	(dBuV/m)	(dBuV/m)	(dB)	(dB)	(dBm)	(dBm)
0.010	60.00	54.00	0.8	6	-59.0	-53.8
0.10	44.35	38.35	0.8	6	-74.6	-69.4
2.00	24.00	18.00	1.3	6	-95.0	-90.3
10.00	24.00	18.00	2.3	6	-95.0	-91.3
29.5	24.00	18.00	4.1	6	-95.0	-93.1
195	29.79	23.79	18.7	N/A	N/A	-101.9
995	43.91	37.91	22.78	N/A	N/A	-91.9
17900	68.95	62.95	41.8	N/A	N/A	-85.8

8.1.6 Test Sample Measurements

With the EUT operating in accordance with Paragraph 5.1, a length of low loss, 50 ohm double shielded coaxial cable was connected to the applicable antenna. The coaxial cable was connected to the interference analyzer located in the ancillary enclosure.

In the frequency range of 10 kHz to 30 MHz, the antenna was positioned to make vertical measurements.

In the frequency range of 30 MHz to 1 GHz, the antennas were positioned to make both vertical and horizontal measurements.

The EMI receiver was controlled by a computer running the EMI measurement software. The software steps the receiver at the required step size and dwell time utilizing the correct 6 dB bandwidth. The software adds the appropriate cable loss, antenna correction factor, and pre-amplifier correction factor to the recorded data.

Automatic scan data is presented on amplitude versus frequency X-Y axis plot with the applicable specification limit also on the plot. All applicable information for the test is printed on the data plot.

The required frequency range was scanned using the following bandwidths and measurement times in compliance with Table II of MIL-STD-461E:

Bandwidths and Measurement Times

Frequency Range	6 dB Bandwidth	Dwell Time
10 to 150 kHz	1 kHz	0.02 Sec
150 kHz to 30 MHz	10 kHz	0.02 Sec
30 MHz to 1 GHz	100 kHz	0.02 Sec
1 to 18 GHz	1 MHz	0.02 Sec

Synthesized measurement receivers were stepped in one-half bandwidth increments.

Video filtering was not used to bandwidth limit the receiver response. If a controlled video bandwidth was available on the measurement receiver, it was set to its greatest value.

During emissions testing, the EMI receiver was powered through an isolation transformer and its chassis was grounded at a single point. When pre-amps were utilized they were also powered through an audio isolation transformer and were connected at a single point to the grounded chassis of the EMI receiver.

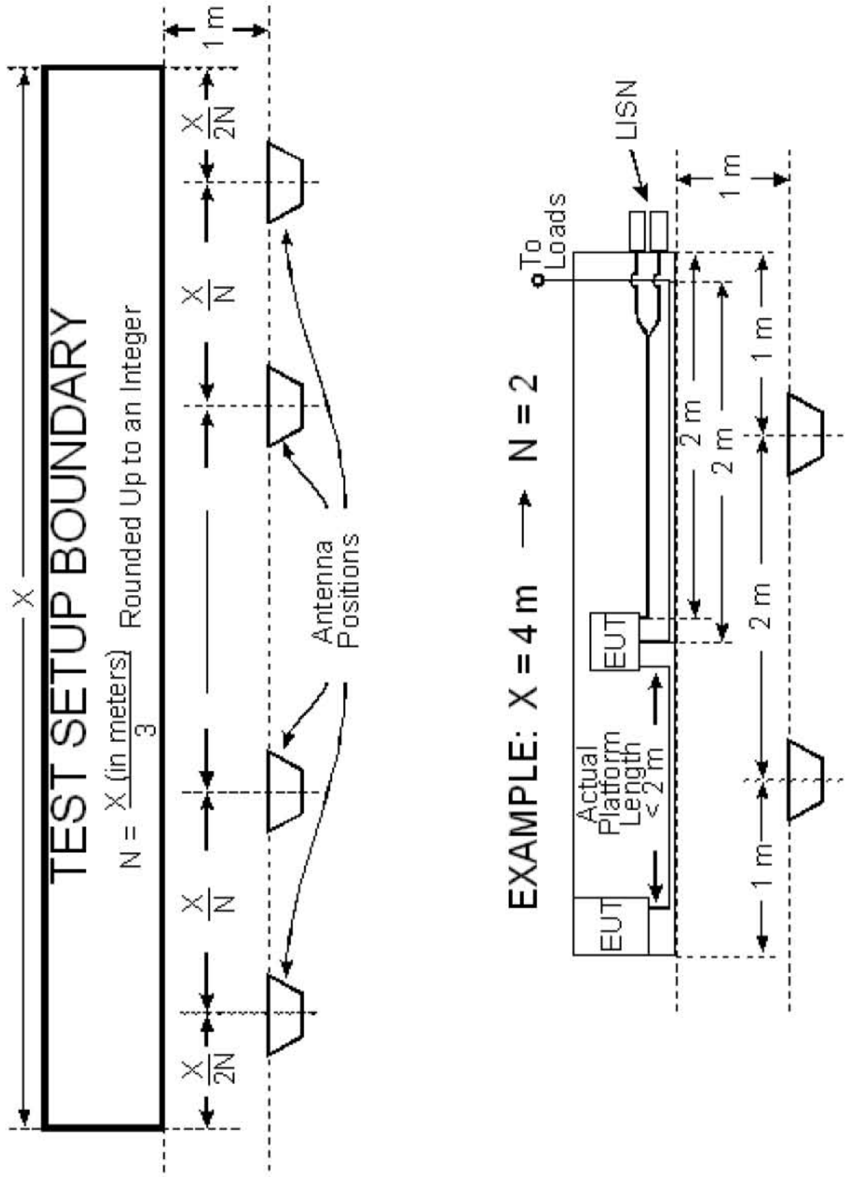
8.1.7 Antenna Positions

In the frequency range of 10 kHz to 200 MHz, the antennas were placed in one position.

In the frequency range of 200 MHz to 1 GHz, the antenna was placed in one position.

In the frequency range of 1 to 18 GHz, the antenna was placed in one position.

8.1.7.1 RE102, Antenna Positions, Below 200 MHz



8.1.7.2 RE102, Antenna Position Calculation, 200 to 1 GHz

3106 Calculations 200 MHz to 1 GHz

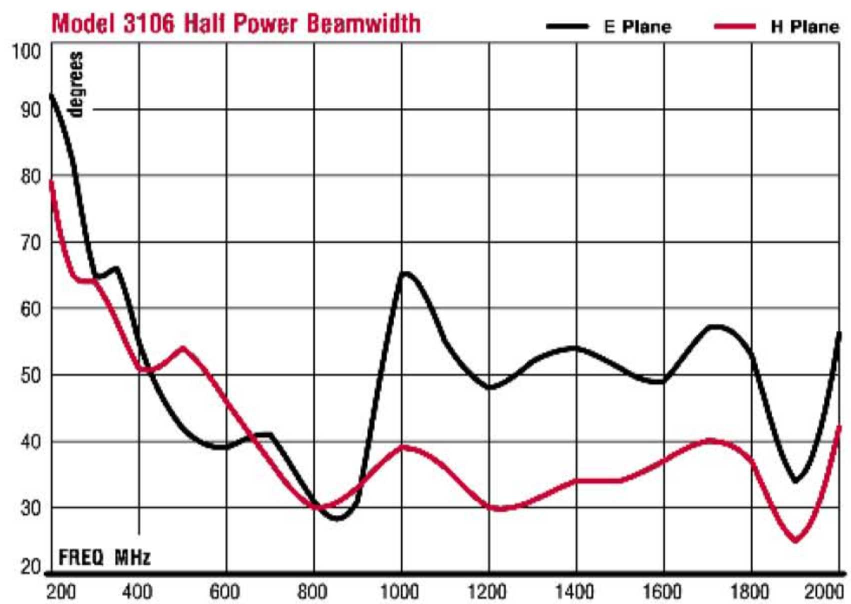
EUT Boundary = 0.45 meters = 1 position

Antenna Length = 0.9m

Antenna Distance = 1.0m

Beamwidth from chart = 28°/2 = 14°

tan 14° = x/1.9m
1.9(tan 14°) = x
0.473 = x
0.947 = 2x
0.947 meter



8.1.7.3 RE102, Antenna Position Calculation, 1 to 18 GHz

Antenna, Model 3117 Calculations 1 to 18 GHz

EUT Boundary = 0.45 meters = 1 position

Antenna Length = 0.175m

Antenna Distance = 1.0m

Beamwidth from chart = 30°/2 = 15°

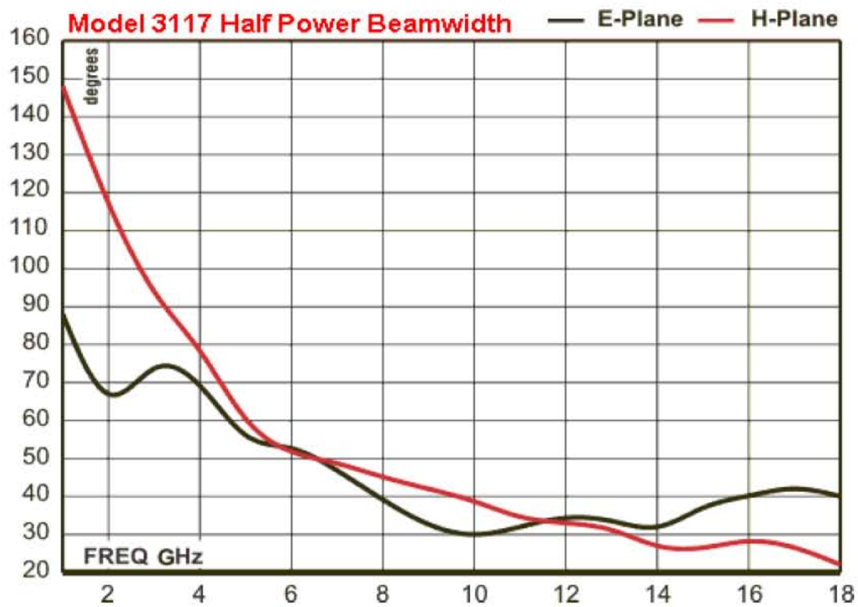
tan 15° = x/1.9m

1.175(tan 15°) = x

0.315 = x

0.63 = 2x

0.63 meter



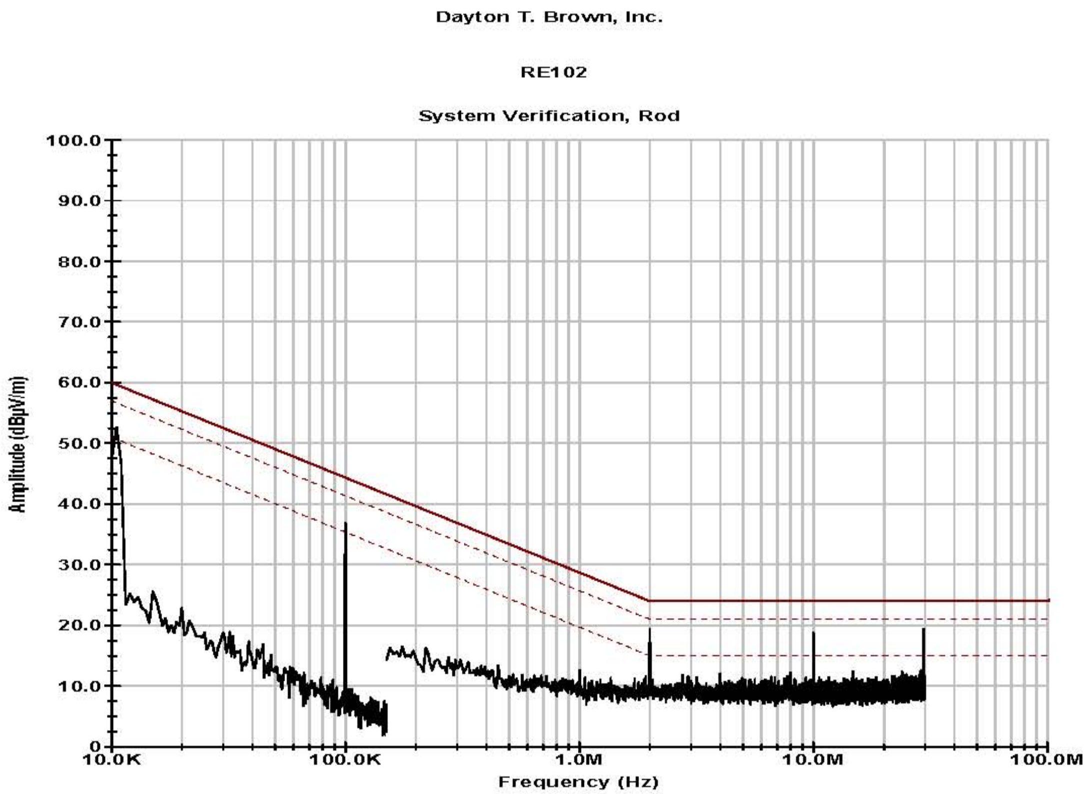
8.1.8 Test Results

The EUT met the requirements of MIL-STD-461E, Method RE102.

No emissions above the MIL-STD-461E, Method RE102 limit were observed.

See the following test data for detailed test results.

8.1.8.1 RE102, Calibration Verification



Operator: P. Kelly

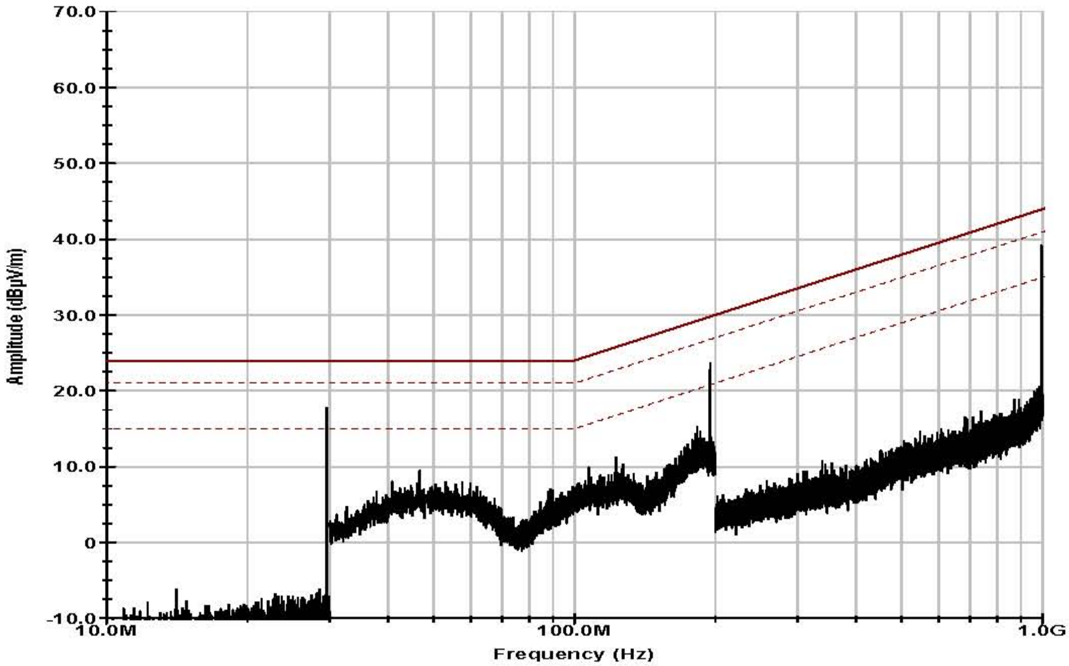
RE102-3 Calibration.TIL

10:37:12 AM, Monday, February 02, 2009

Dayton T. Brown, Inc.

RE102

System Verification, Cable Input



Operator: P. Kelly

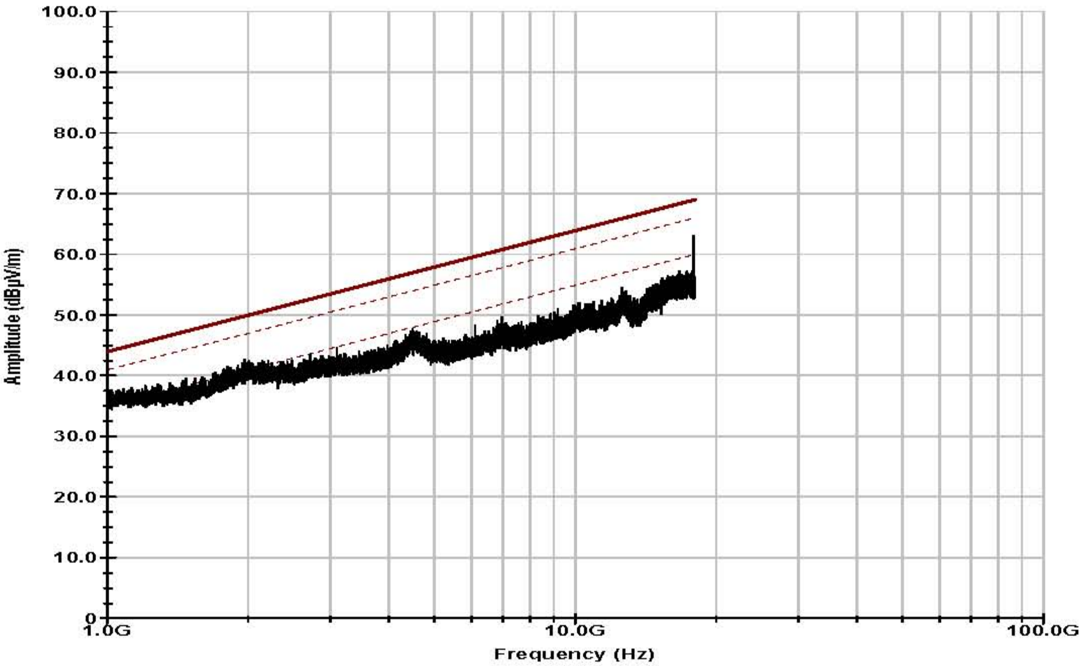
RE102-3 Calibration.TIL

10:47:48 AM, Monday, February 02, 2009

Dayton T. Brown, Inc.

RE102

System Verification, Cable Input



Operator: P. Kelly

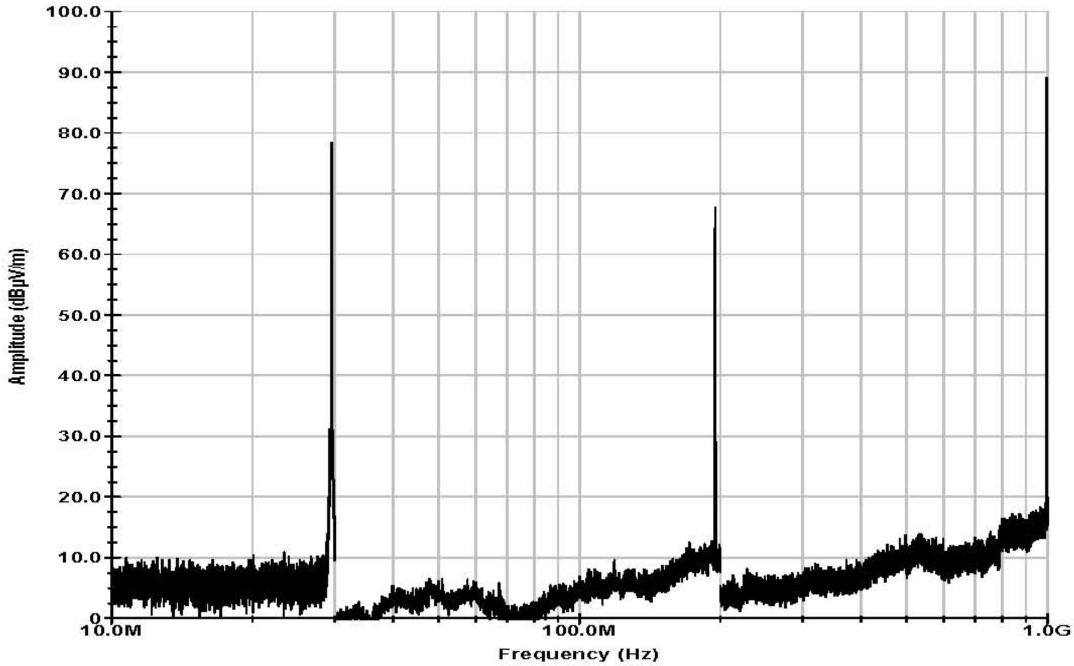
RE102-3 Above 1 GHz Cal.TIL

12:09:43 PM, Monday, February 02, 2009

Dayton T. Brown, Inc.

RE102

System Verification, Radiating Stub



Operator: P. Kelly

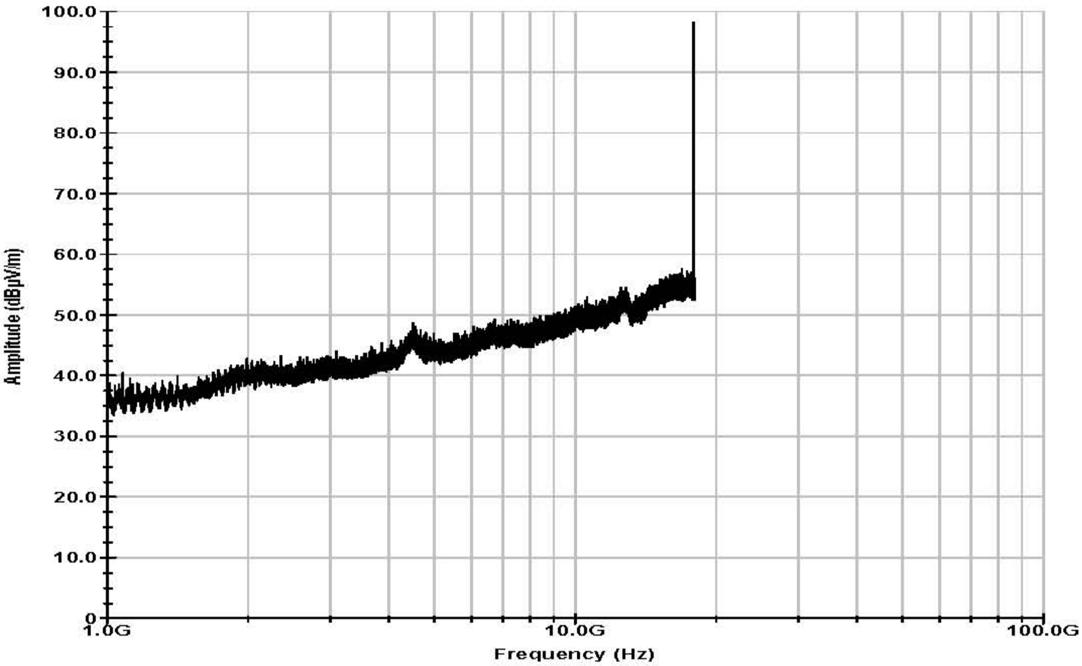
RE102-3 Calibration.TIL

10:55:58 AM, Monday, February 02, 2009

Dayton T. Brown, Inc.

RE102

System Verification, Radiating Stub



Operator: P. Kelly

RE102-3 Above 1 GHz Cal.TIL

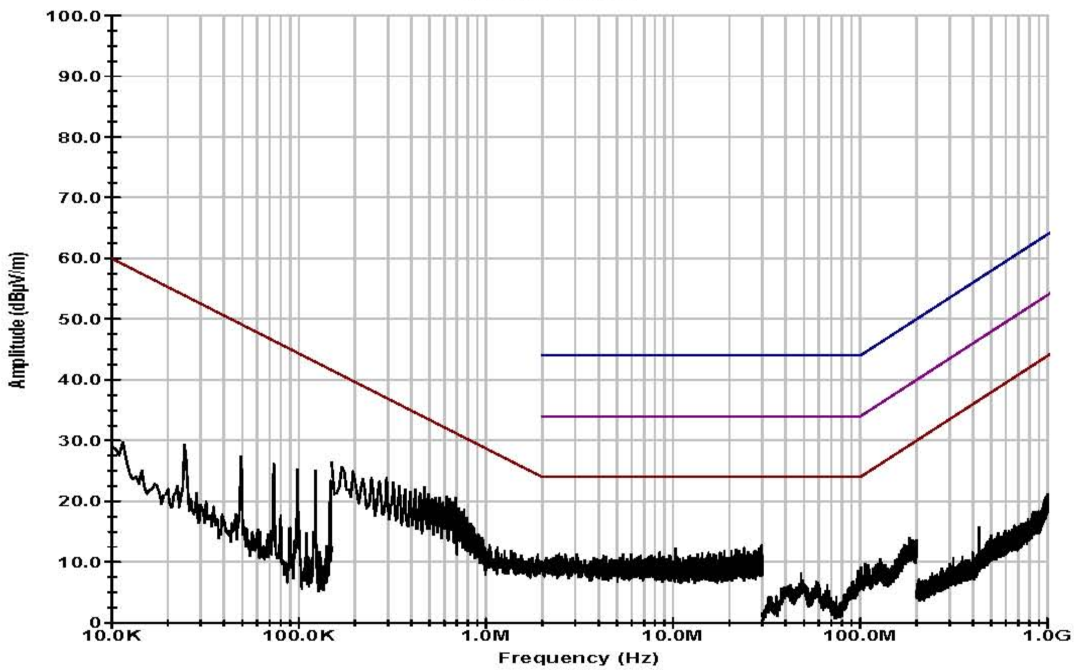
12:13:22 PM, Monday, February 02, 2009

8.1.8.2 RE102, Operational Scans

Dayton T. Brown, Inc.

RE102

Results, Vertical

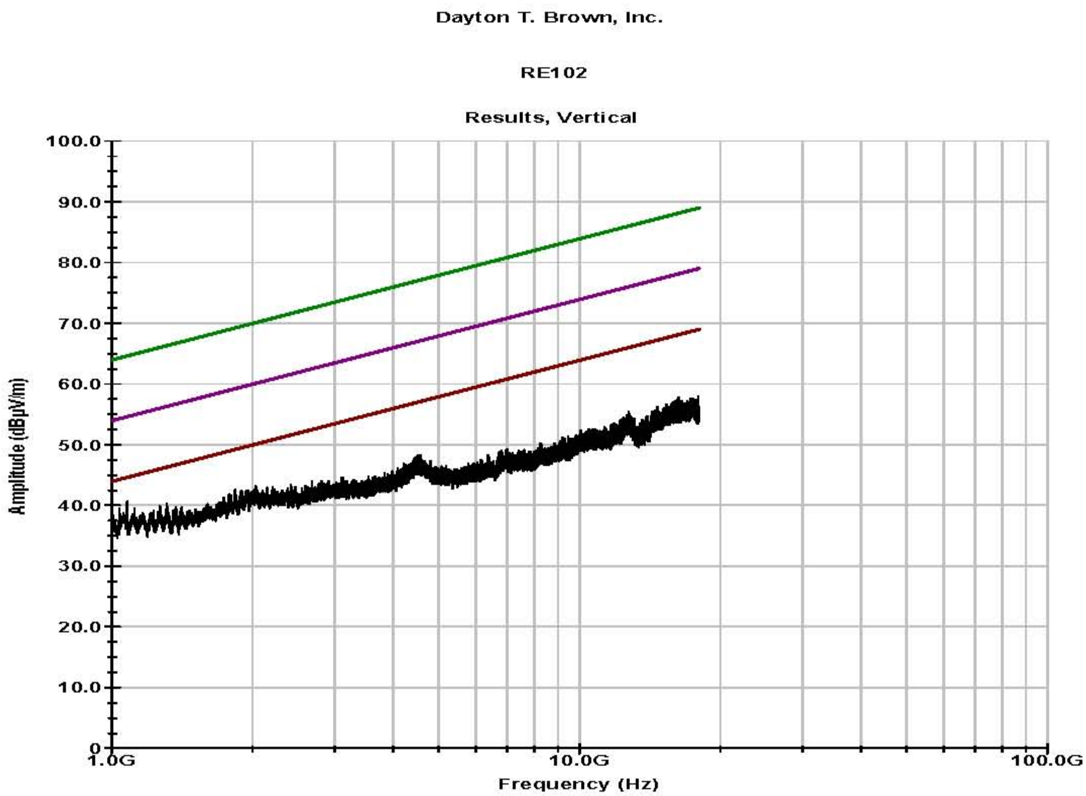


Operator: P. Kelly

RE102-3 Operational.TIL

11:30:23 AM, Monday, February

Test Item - Aircrew Seat Cushion
Serial No. -
Model / Part No. -
Mode of Op - Operational
Job Number - 410741-00-000
Antenna Location - 1 Meter Distance
Contact - ÿ

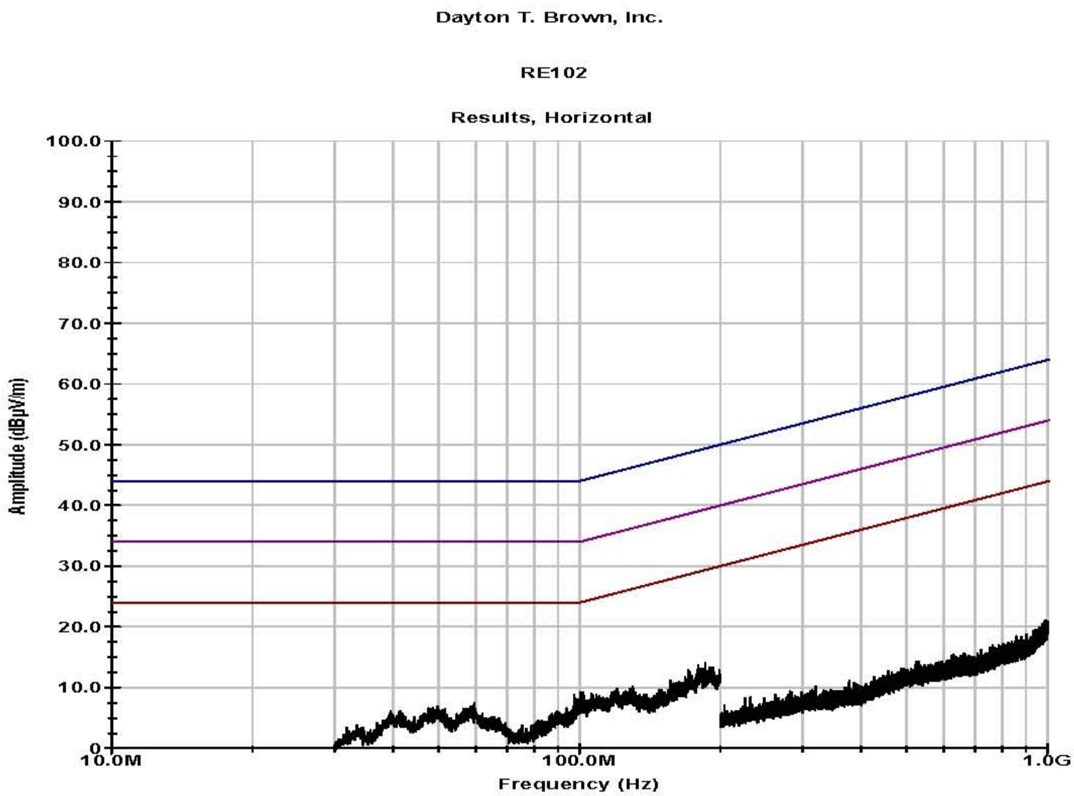


Operator: P. Kelly

RE102-3 Above 1 GHz Operatio

01:14:19 PM, Monday, February

Test Item - B2 Seat Cushoin
Serial No. -
Model / Part No. -
Mode of Op - Operational
Job Number - 410741-00-000
Antenna Location - 1 Meter Distance
Contact - ÿ

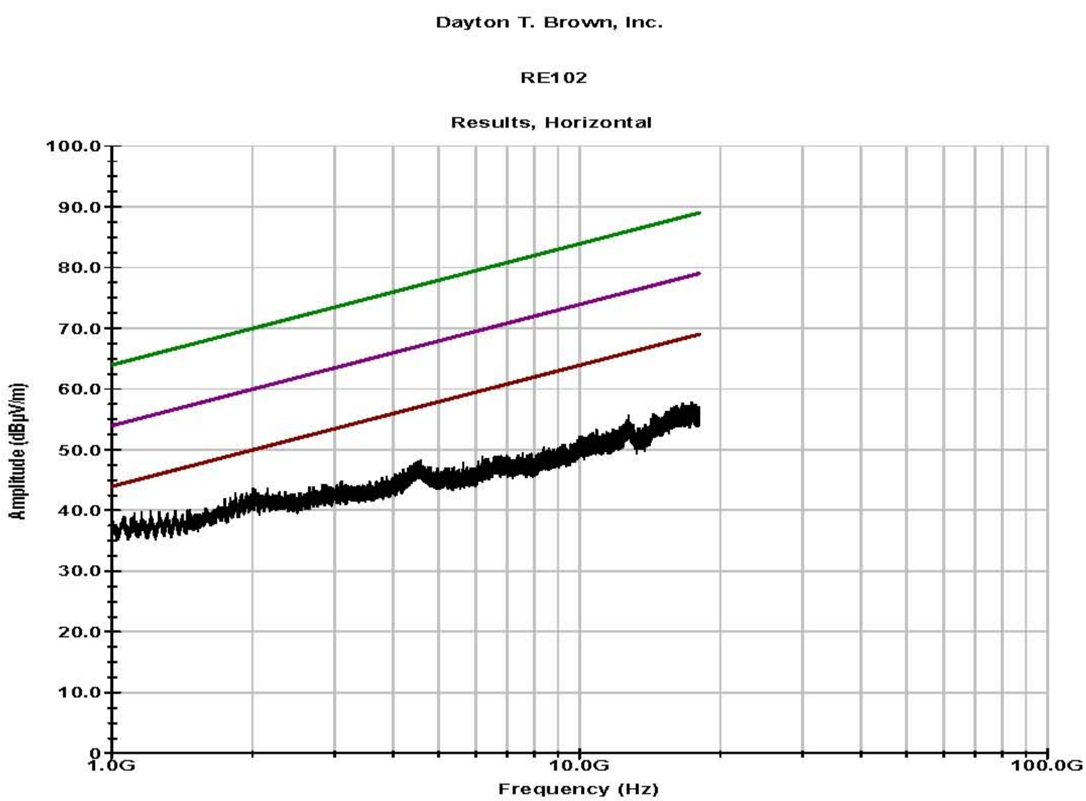


Operator: P. Kelly

RE102-3 Operational.TIL

11:30:23 AM, Monday, Februar

Test Item - Aircrew Seat Cushion
Serial No. -
Model / Part No. -
Mode of Op - Operational
Job Number - 410741-00-000
Antenna Location - 1 Meter Distance
Contact - ÿ



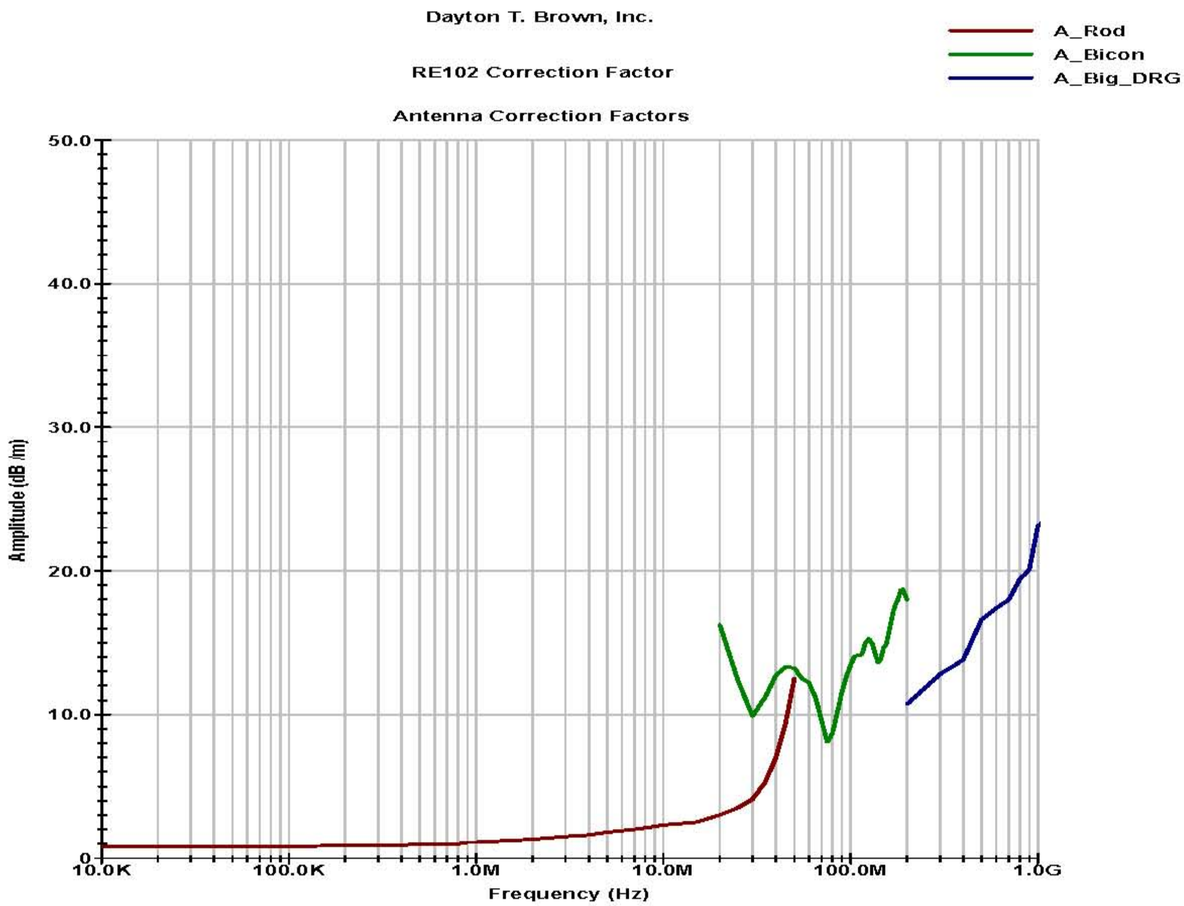
Operator: P. Kelly

RE102-3 Above 1 GHz Operatio

01:14:19 PM, Monday, Februar

Test Item - B2 Seat Cushoin
Serial No. -
Model / Part No. -
Mode of Op - Operational
Job Number - 410741-00-000
Antenna Location - 1 Meter Distance
Contact - ÿ

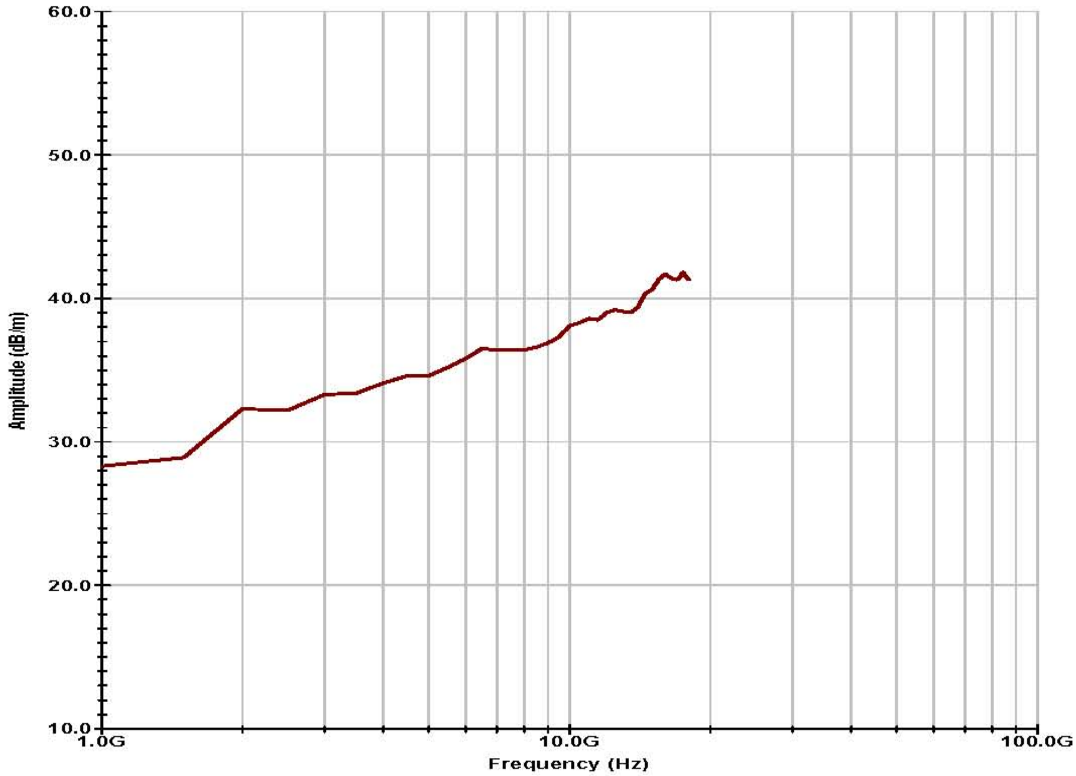
8.1.9 Correction Factors

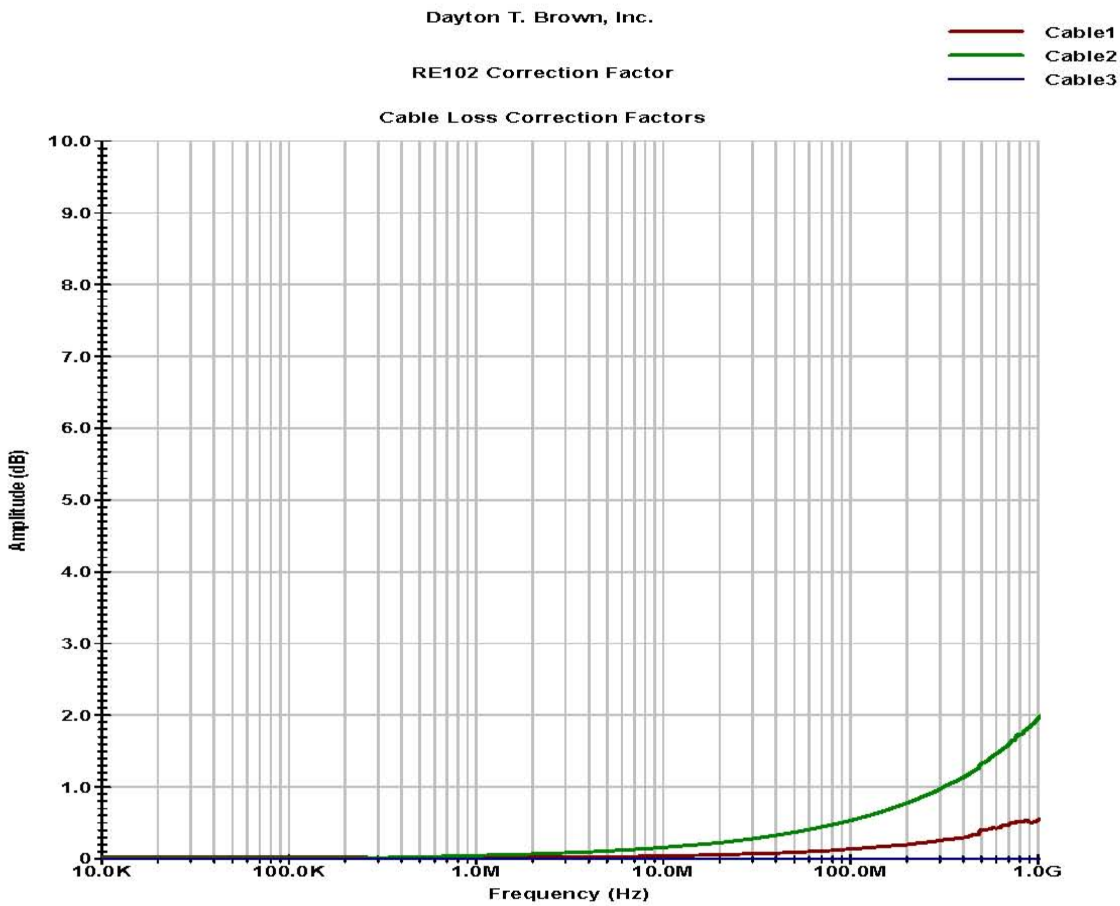


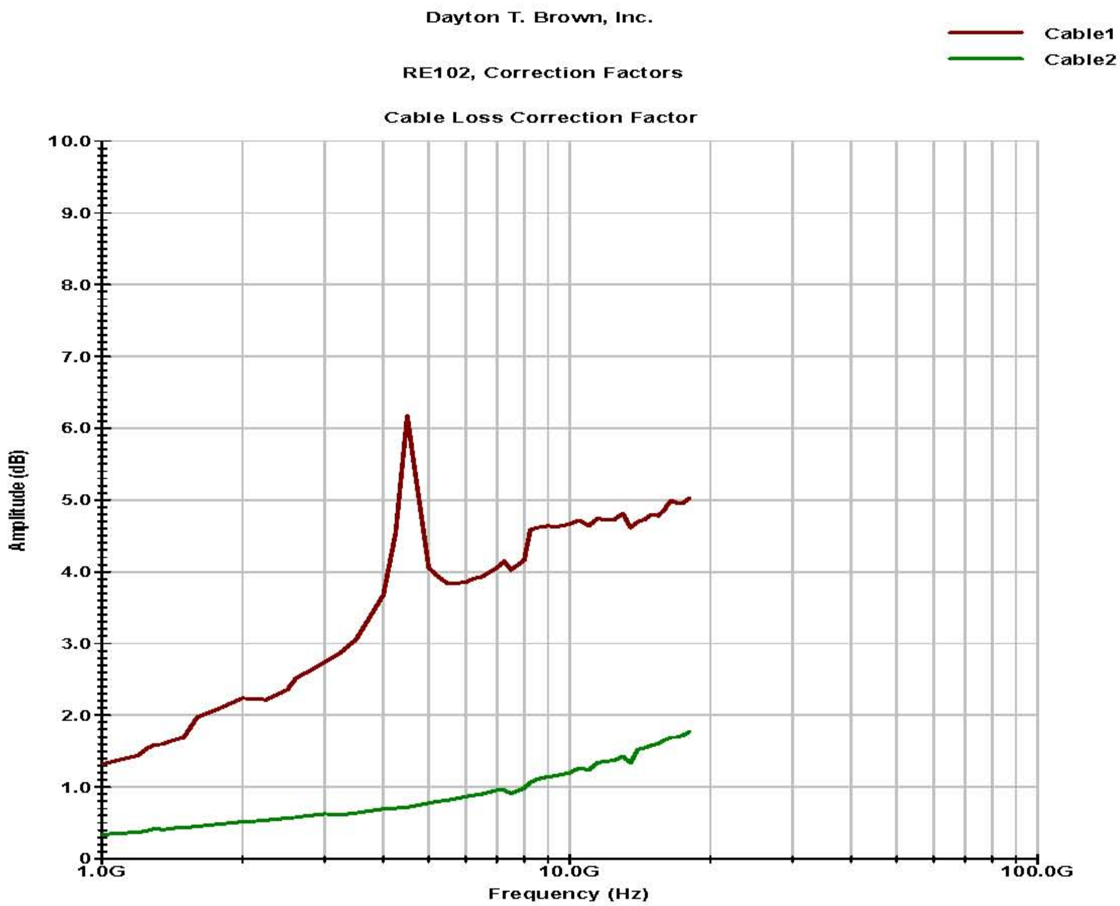
Dayton T. Brown, Inc.

RE102, Correction Factors

Antenna Correction Factor



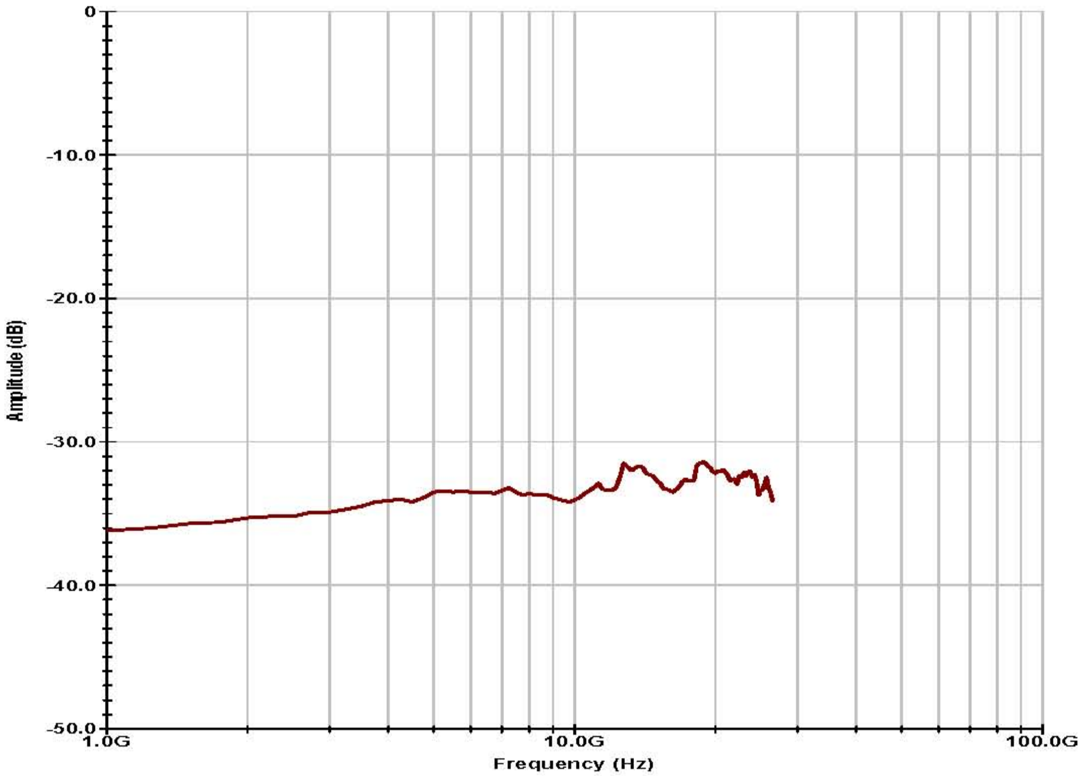

Dayton T. Brown, Inc.
RE102 Correction Factor
Cable Loss Correction Factors
Cable1
Cable2
Cable3
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
Amplitude (dB)
10.0K
100.0K
1.0M
10.0M
100.0M
1.0G
Frequency (Hz)


Dayton T. Brown, Inc.
RE102, Correction Factors
Cable Loss Correction Factor
Cable1
Cable2
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
Amplitude (dB)
1.0G
10.0G
100.0G
Frequency (Hz)

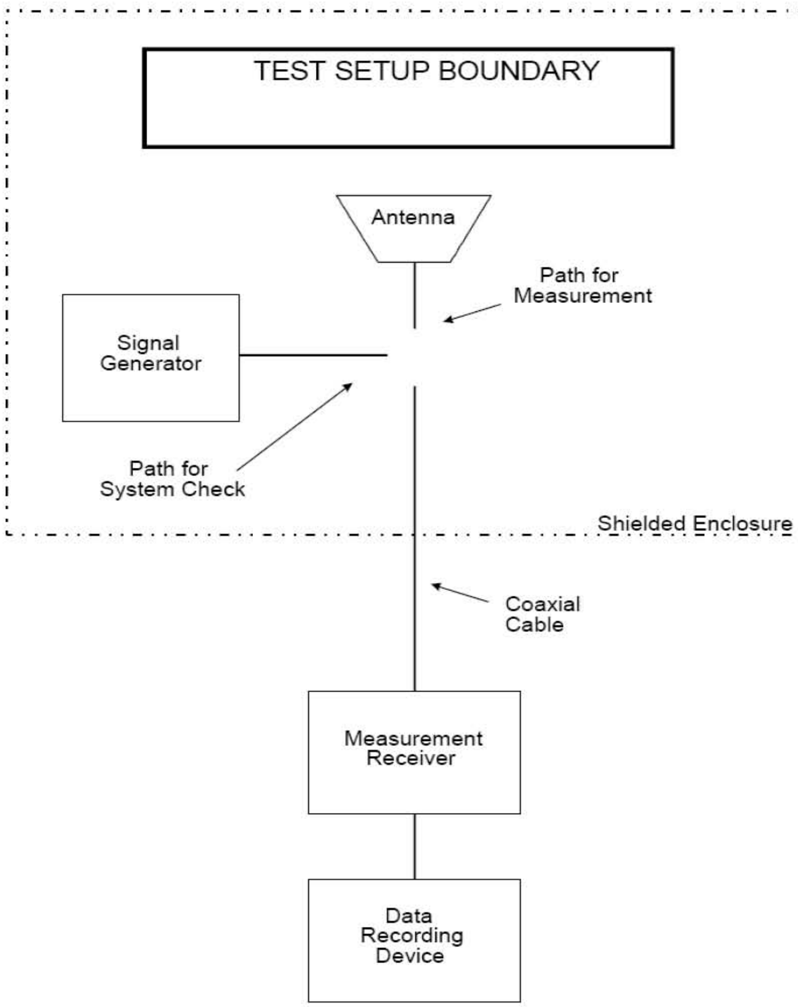
Dayton T. Brown, Inc.

RE102, Correction Factors

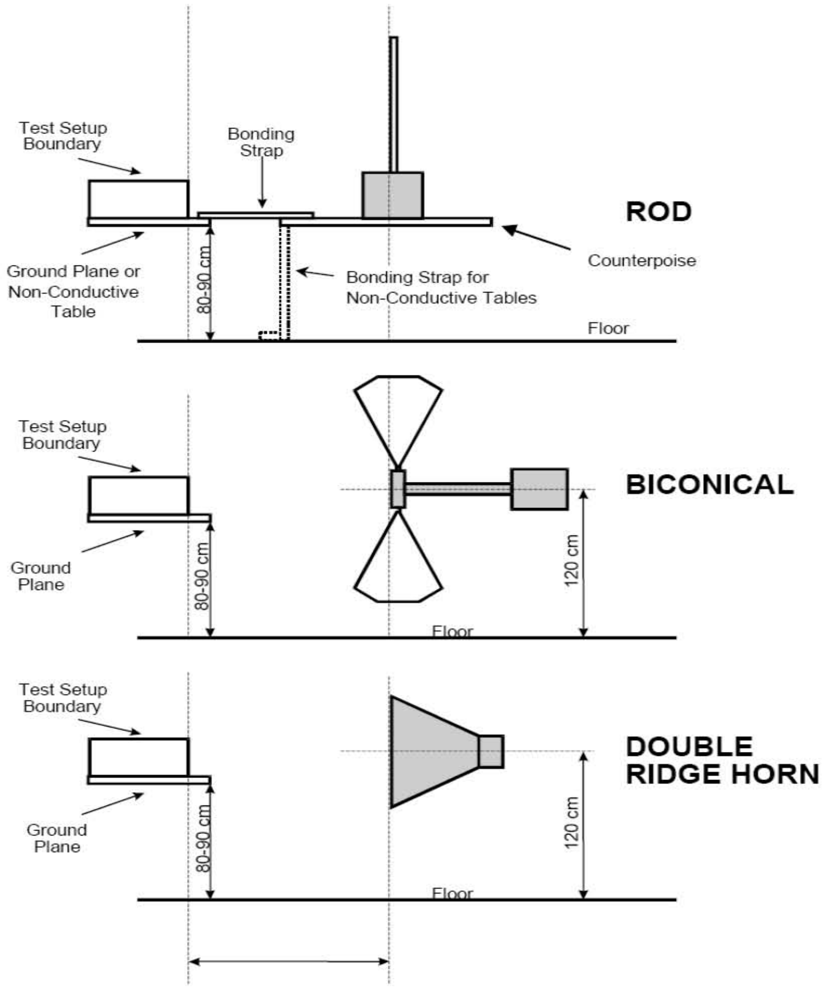
Pre-Amplifier Correction Factor



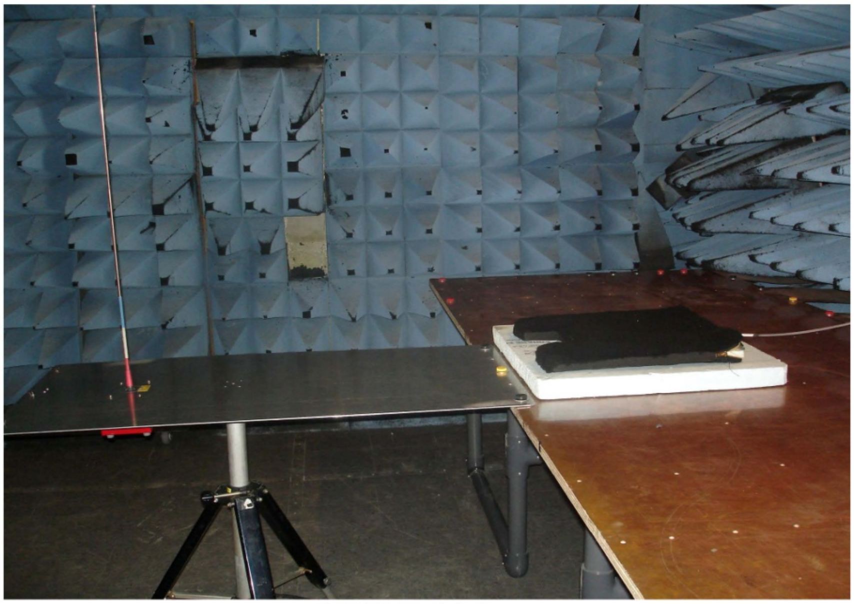
8.1.10 RE102, Test Setup Diagram



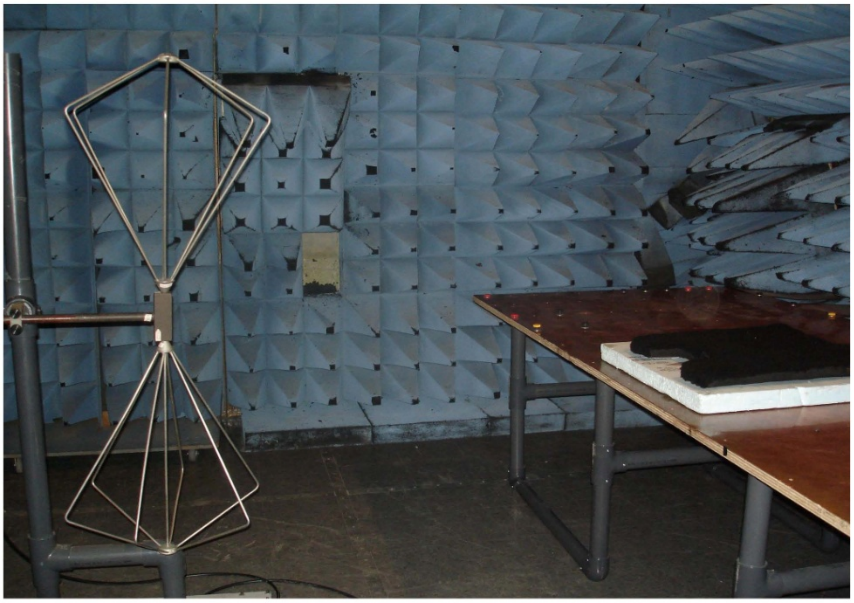
8.1.11 RE102, Antenna Positioning Diagram



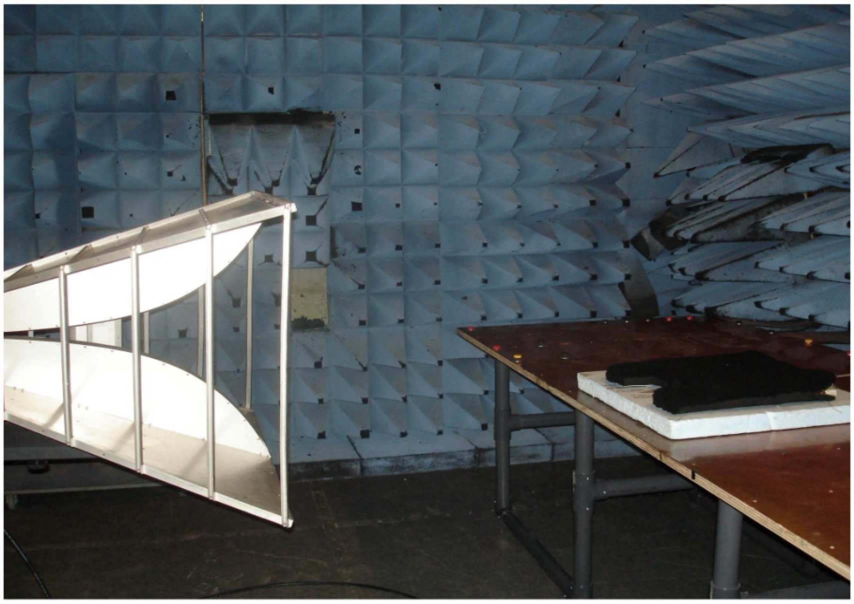
8.1.12 RE102, Test Setup Photographs



RE102, Rod Antenna



RE102, Biconical Antenna



RE102, Double Ridge Waveguide Antenna

RE102, Double Ridge Waveguide Antenna

8.2 Radiated Susceptibility, Method RS103, Electric Field

8.2.1 Purpose

The purpose of this test is to verify the ability of the EUT and associated cabling to withstand electric fields.

8.2.2 Limit

MIL-STD-461E, Level of 60 V/m for the frequency range of 2 MHz to 18 GHz.

8.2.3 Test Setup

The test setup was as detailed in Paragraph 6.4 of this document.

All antennas were located at a distance of 1.0 meter from the test setup boundary. The electric field sensor was placed 1.0 meter from and directly opposite the transmit antenna. The sensor was not placed directly at corners or edges of the EUT. The electric field sensor was at least 30 cm above the ground plane and away from any metal.

8.2.4 Equipment List

ITEM	MANUFACTURER	MODEL	DTB NO.	CAL DUE DATE
ANECHOIC CHAMBER, #1 20' X 20' X 12'	RAYPROOF	81	01E-026	No Calib Required
ANECHOIC CHAMBER, #1 20' X 20' X 12'	RAYPROOF	81	01E-026	No Calib Required
GENERATOR, AM/FM SIGNAL 9KHZ - 1.2 GHZ	IFR	2023A	24-24	05/31/2009
GENERATOR, SYNTHESIZED SWEEPER	AGILENT TECHNOLOGIES	83640B	24-29	01/03/2010
ANTENNA, E FIELD GENERATOR	AMPLIFIER RESEARCH	AT3000	27-31	No Calib Required
ANTENNA, BICONICAL	EMCO	3109	27-33	No Calib Required
ANTENNA, HIGH GAIN HORN N-CONNECTOR	AMPLIFIER RESEARCH	AT4002A	27-373	12/06/2009
ANTENNA, DOUBLE RIDGE WAVEGUIDE HORN 750 MHZ TO 18 GHZ	ETS-LINDGREN	3115	27-39	08/23/2009
ANTENNA, DOUBLE RIDGED GUIDE	EMCO	3106	27-42	05/24/2009
ANTENNA, DOUBLE-RIDGE WAVEGUIDE INPUT HORN 8 - 18 GHZ	MICROWAVE ENGINEERING CORP	R390-11	27-51	05/16/2010
POWER SUPPLY, DC	POWER DESIGNS	5030	36-6	03/21/2010
PROBE, ISOTROPIC FIELD 10 KHZ - 1000 MHZ	AMPLIFIER RESEARCH	FP4000	65-189	10/25/2009
AMPLIFIER, BROAD BAND	AMPLIFIER RESEARCH	2500L	71-34	No Calib Required
AMPLIFIER, TRAVELING WAVE TUBE	LOGIMETRICS	A600/S	71-35	No Calib Required
AMPLIFIER, TRAVELING WAVE TUBE	AMPLIFIER RESEARCH	500T2G8	71-42	No Calib Required
AMPLIFIER, RF POWER	AMPLIFIER RESEARCH	1000W1000C	71-45	No Calib Required
AMPLIFIER, TRAVELING WAVE TUBE	ASE	200X/KU	71-9	No Calib Required
CABLE, TEST	PASTERNACK	RG214/U	7-56	11/01/2009
CABLE, TEST	PASTERNACK	RG214/U	7-6	11/01/2009
CABLE, TYPE N MALE TO MALE TEST	PASTERNACK	RG214/U	7-84	10/11/2009
MULTIMETER, TRUE RMS	FLUKE	87 SERIES V	9-167	11/15/2009

8.2.4.1 Software

Software	Manufacturer	Version
TILE!	Quantum Change	3.4.K.29

8.2.5 Antenna Positions

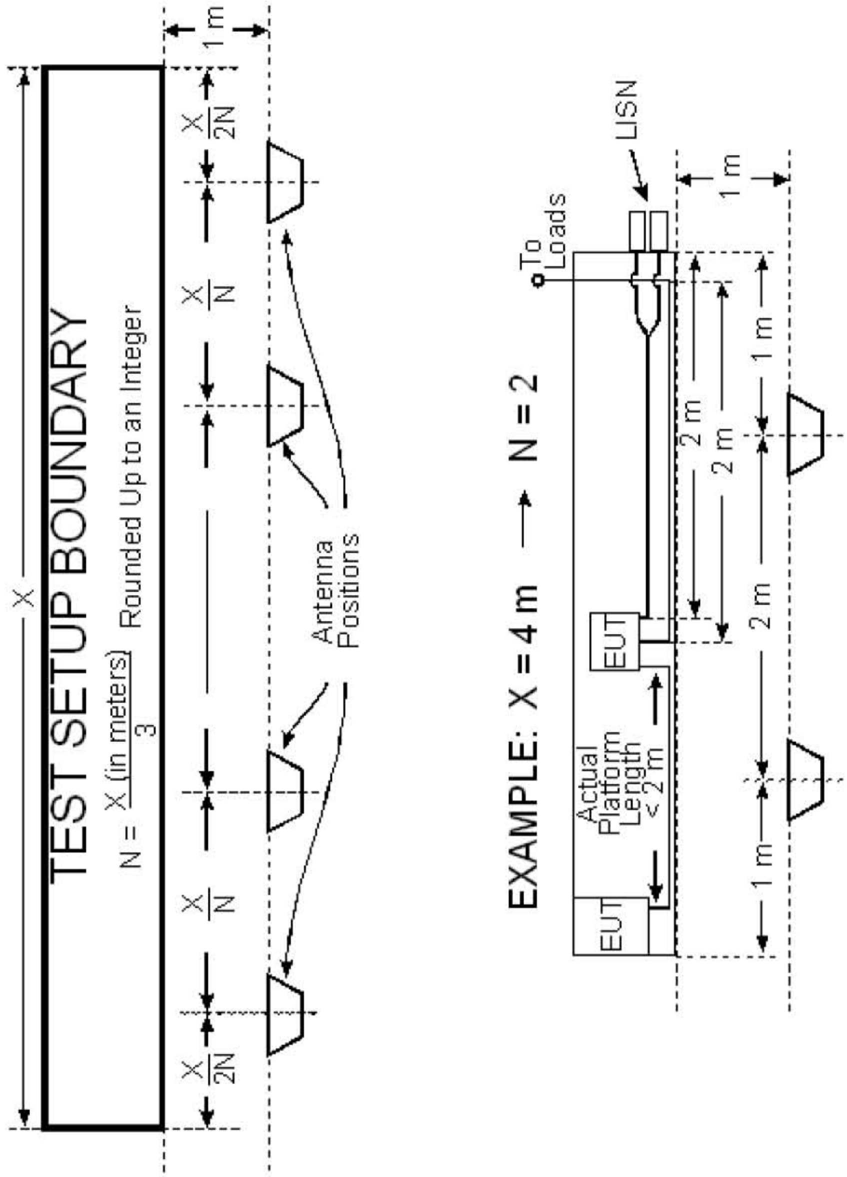
In the frequency range of 2 to 200 MHz, the antennas were placed in one position.

In the frequency range of 200 MHz to 1 GHz, the antenna was placed in one position.

In the frequency range of 1 to 12.4 GHz, the antenna was placed in one position.

In the frequency range of 12.4 to 18 GHz, the antenna was placed in one position.

8.2.5.1 RS103, Antenna Positions, Below 200 MHz



8.2.5.3 RS103, Antenna Position Calculation, 1 to 12.4 GHz

Antenna, Model AT4002A Calculations 1 to 12.4 GHz

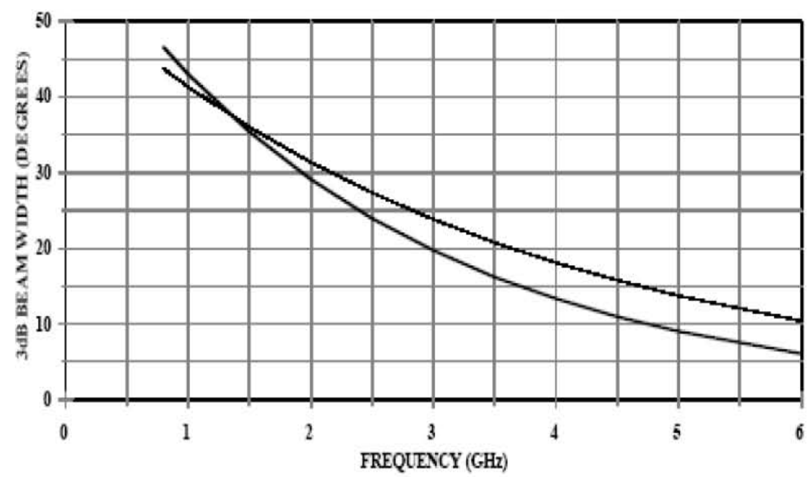
EUT Boundary = 0.45 meters = 1 position

Antenna Length = 0.6m

Antenna Distance = 1.0m

Beamwidth from chart = 18°/2 = 9°
tan 9° = x/1.6m
1.6(tan 9°) = x
0.253 = x
0.506 = 2x
0.506 meter

Model AT4002A BEAMWIDTH VS FREQUENCY



8.2.5.4 RS103, Antenna Position Calculation, 4 to 8 GHz

Antenna, Model 3115 Calculations 4 to 8 GHz

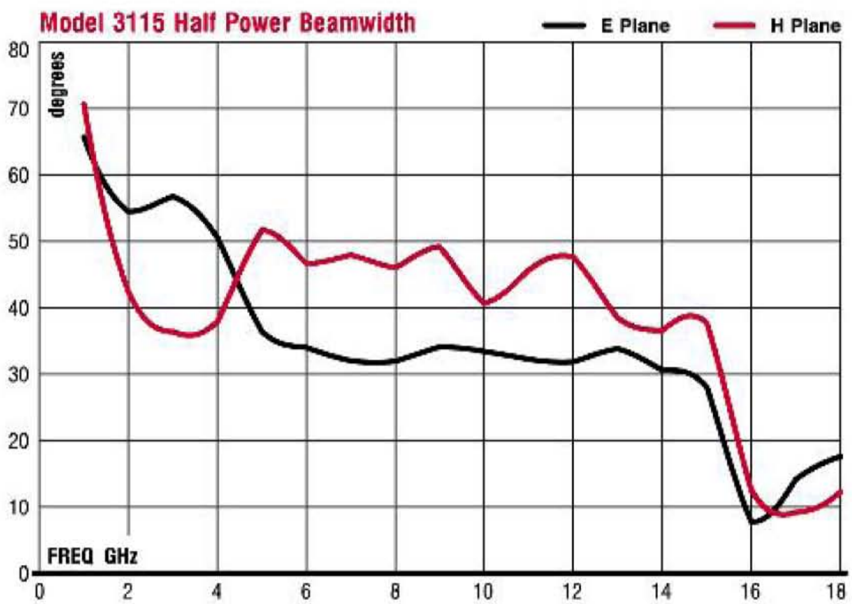
EUT Boundary = 0.45 meters = 1 position

Antenna Length = 0.2m

Antenna Distance = 1.0m

Beamwidth from chart = 30°/2 = 15°

tan 15° = x/1.2m
1.2(tan 15°) = x
0.322 = x
0.644 = 2x
0.644 meter



8.2.5.5 RS103, Antenna Position Calculation, 8 to 18 GHz

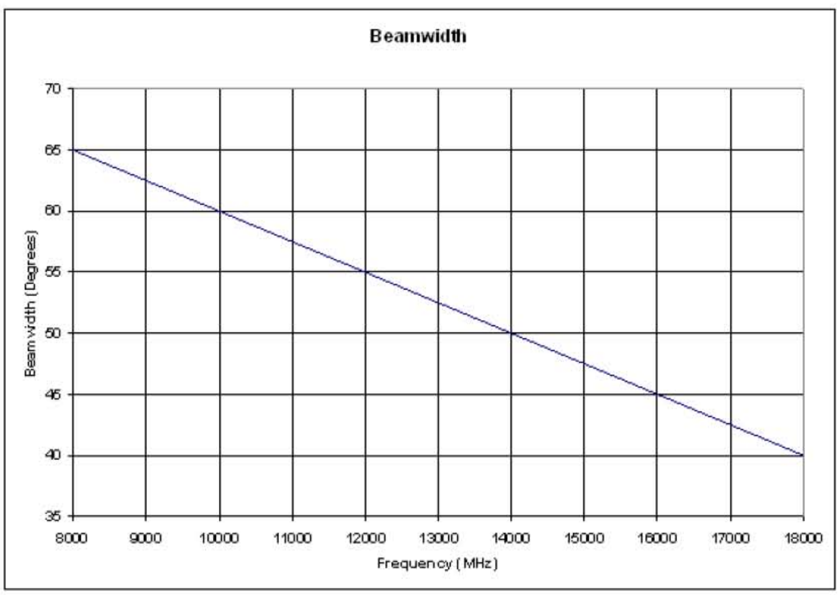
Antenna, Model R390-11 Calculations 8 to 18 GHz

EUT Boundary = 0.45 meters = 1 position

Beamwidth from MFR Data = 40°/2 = 20°

tan 20° = x/1.0559m
1.0559 ? tan 20° = x
0.384 = x
0.77 = 2x
0.77 meter

The EUT Boundry includes all EUT components and a minimum of the first 7cm of cables from each EUT component.



8.2.6 Calibration

With the EUT operating in accordance with Paragraph 5.1, the field sensor was positioned so that amplitude observed on the meter was less than 10% of the required field strength for the test. This was to ensure the EUT ambient did not affect the testing.

8.2.7 Susceptibility Evaluation Test Procedure

The frequency range of the test was 2 MHz to 18 GHz.

The signal generator was set to be pulse modulated with a 1 kHz square wave (50% duty cycle).

With the EUT operating in accordance with Paragraph 5.1, each antenna was connected to the signal source with a length of 50 ohm coaxial cable. The signal generator was set to the start frequency and the output level was increased until the required field strength was indicated on the field sensor meter. While scanning the frequency range, the required field level was maintained via a closed loop fiber optic output from the field sensor to the RF signal source.

The frequency range was scanned at the rates specified in a table in this document. While scanning, the EUT was monitored for performance as per the requirements in Paragraph 5.2. The above process was repeated for each antenna frequency range and antenna position and polarization.

Below 30 MHz, the antenna was positioned to radiate a vertically polarized field.

Above 30 MHz, the antennas were positioned to radiate both vertically and horizontally polarized fields.

8.2.8 Test Results

The EUT met the requirements of MIL-STD-461E, Method RS103.

No change in indication, malfunction, or degradation in the EUT operation was observed during the MIL-STD-461E, Method RS103 test.

See the following test data for detailed test results.

8.2.8.1 RS103, Test Data

Test Item:	B2 Seat Cushion	Date:	02/02/2009
Customer:	Infoscitex Corp.	Serial No:	EMI
Test Mode:	Operational	Job No:	410741-00-000
Specification:	MIL-STD-461E		
Procedure:	RS103	Technician:	P. Kelly

Radiated Susceptibility, Method RS103 Met Requirement Yes ☒ No ☐

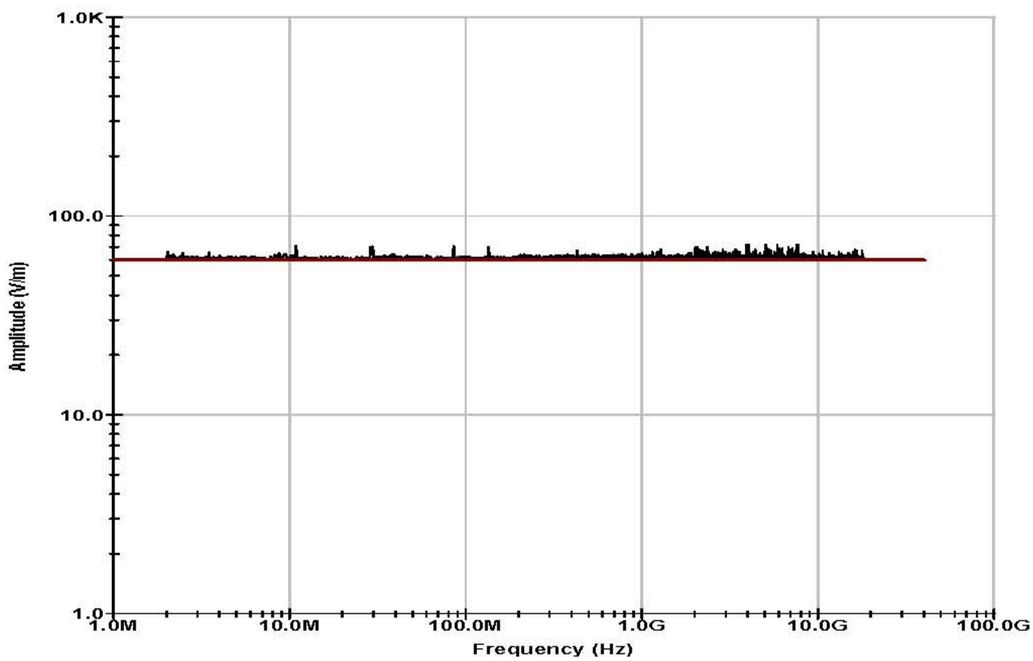
Frequency (MHz) Start	Frequency (MHz) Stop	Scan Rate Step Size	Scan Rate Dwell (sec)	Field Level (V/m)	Modulation	Field Polarization	Susceptibility Threshold Freq (MHz)	Susceptibility Threshold Level (dBµA)	Observation
2.0	30	0.01 fo	3	60	1 kHz pulse, 50% Duty Cycle	Vertical			No change in test sample operation.
30	1000	0.005 fo	3	60	1 kHz pulse, 50% Duty Cycle	Vertical			No change in test sample operation,
1000	8000	0.001 fo	3	60	1 kHz pulse, 50% Duty Cycle	Vertical			No change in test sample operation.
8000	18000	0.0005 fo	3	60	1 kHz pulse, 50% Duty Cycle	Vertical			No change in test sample operation.
30	1000	0.005 fo	3	60	1 kHz pulse, 50% Duty Cycle	Horizontal			No change in test sample operation.
1000	8000	0.001 fo	3	60	1 kHz pulse, 50% Duty Cycle	Horizontal			No change in test sample operation.
8000	18000	0.0005 fo	3	60	1 kHz pulse, 50% Duty Cycle	Horizontal			No change in test sample operation.

Remarks:

Dayton T. Brown, Inc.

RS103

Vertical



Test Item - Aircrew Seat Cushion

Operator: P. Kelly

Serial Number -

RS103.TIL

Job Number - 410741-00-000

›oration

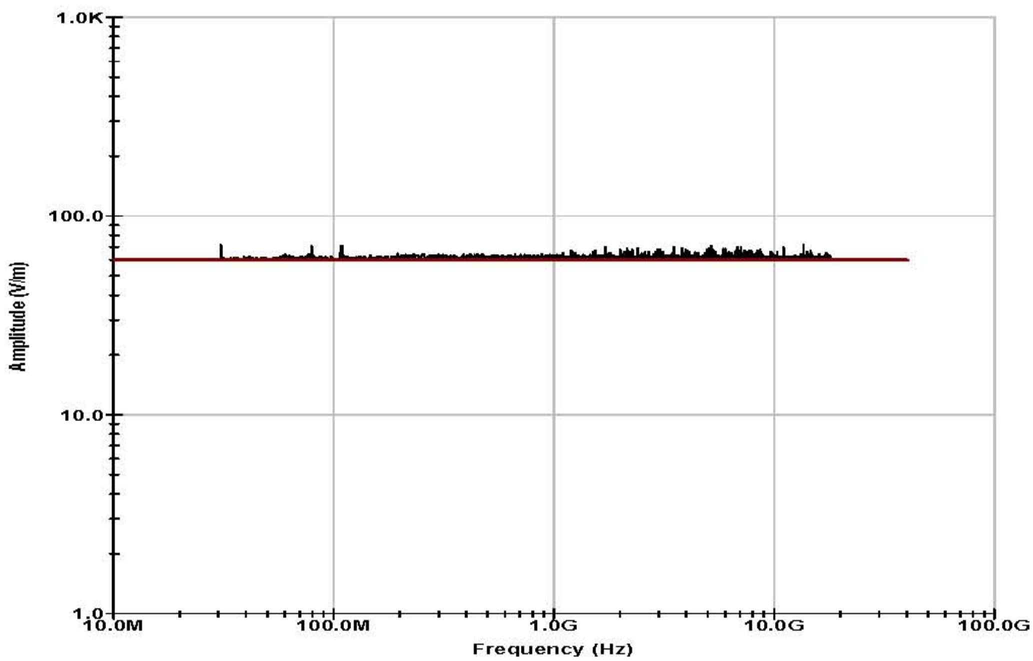
12:55:50 PM, Sunday, February 01, 2009

Engineer: S. Delurey

Dayton T. Brown, Inc.

RS103

Horizontal



Test Item - Aircrew Seat Cushion

Operator: P. Kelly

Serial Number -

RS103.TIL

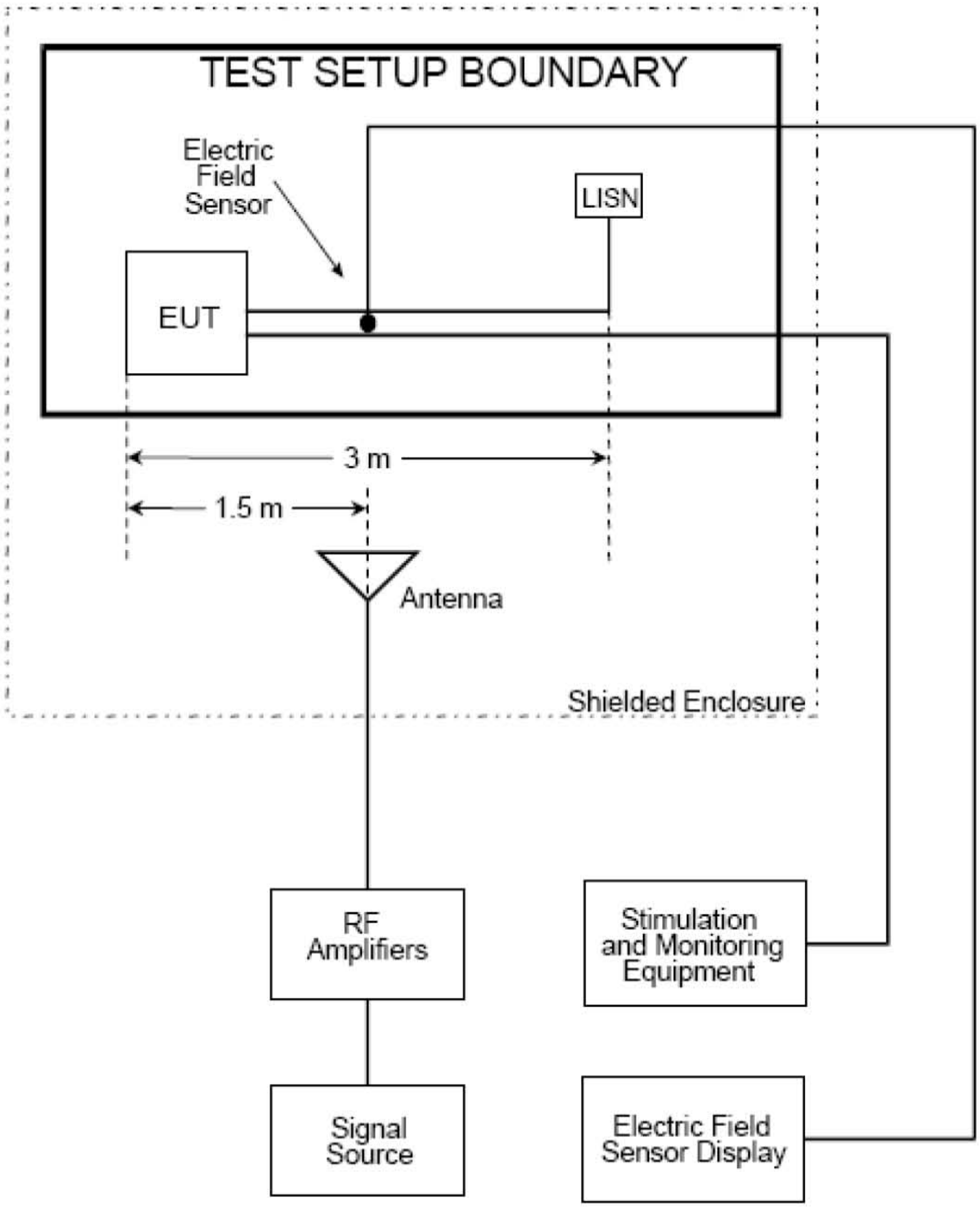
Job Number - 410741-00-000

›oration

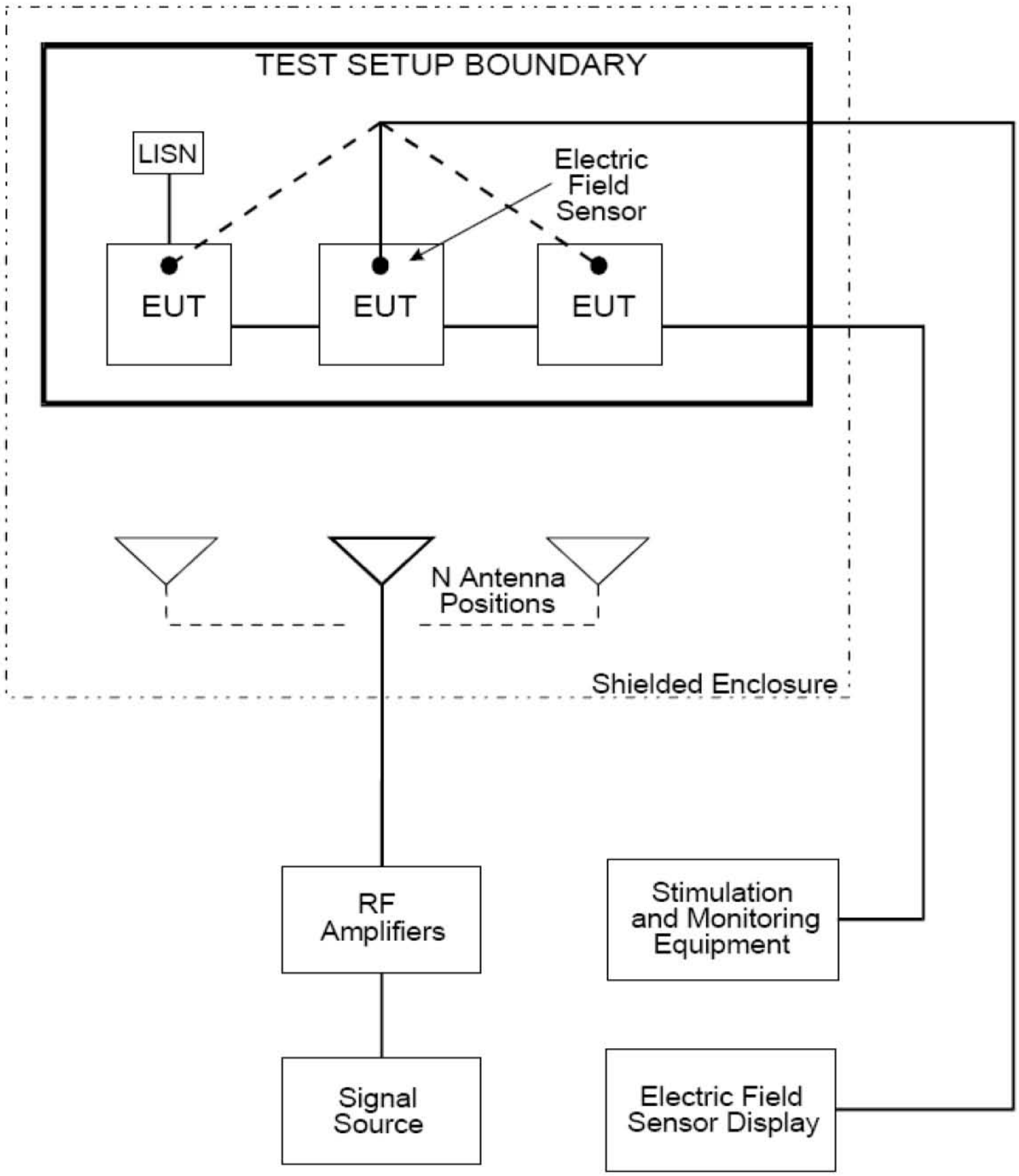
09:23:15 AM, Monday, February 02, 2009

Engineer: S. Delurey

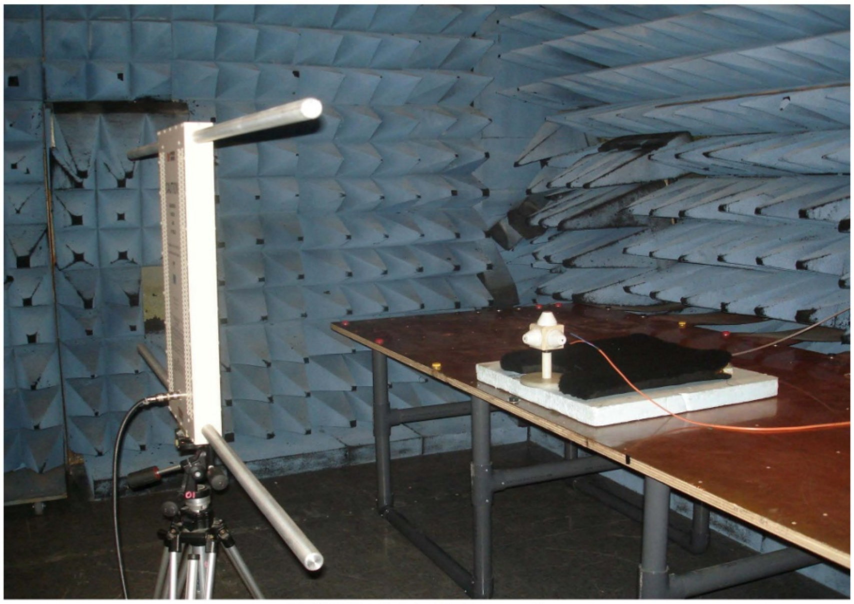
8.2.9 RS103, Test Setup Diagram, Below 200 MHz

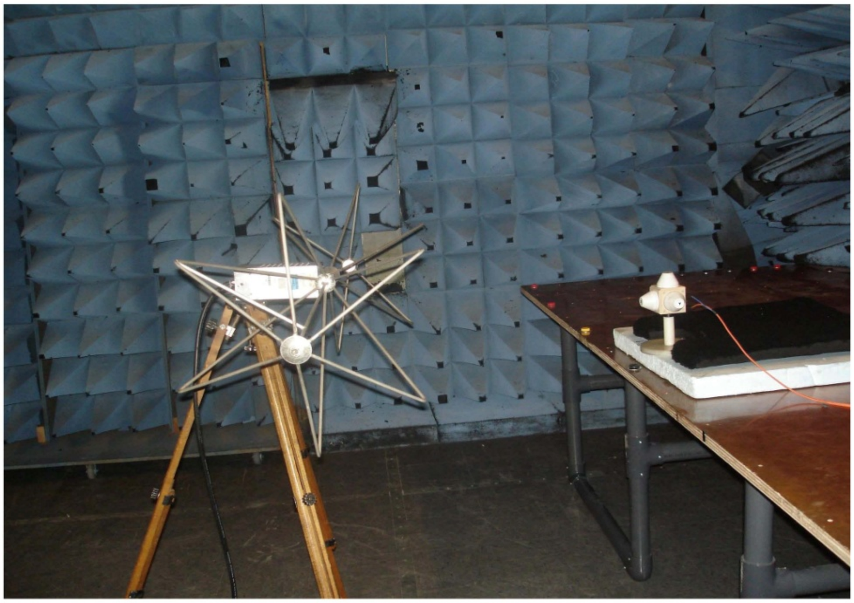


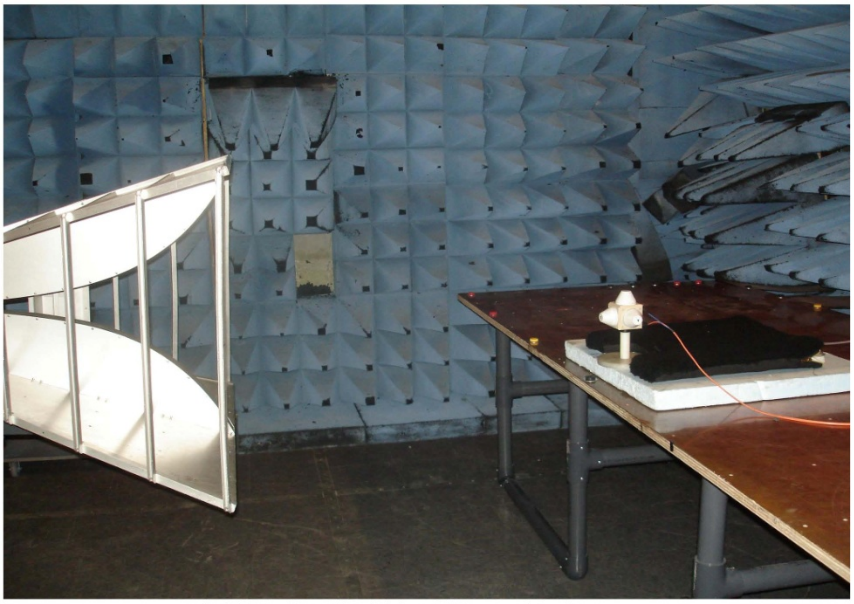
8.2.9.1 RS103, Test Setup Diagram, Above 200 MHz



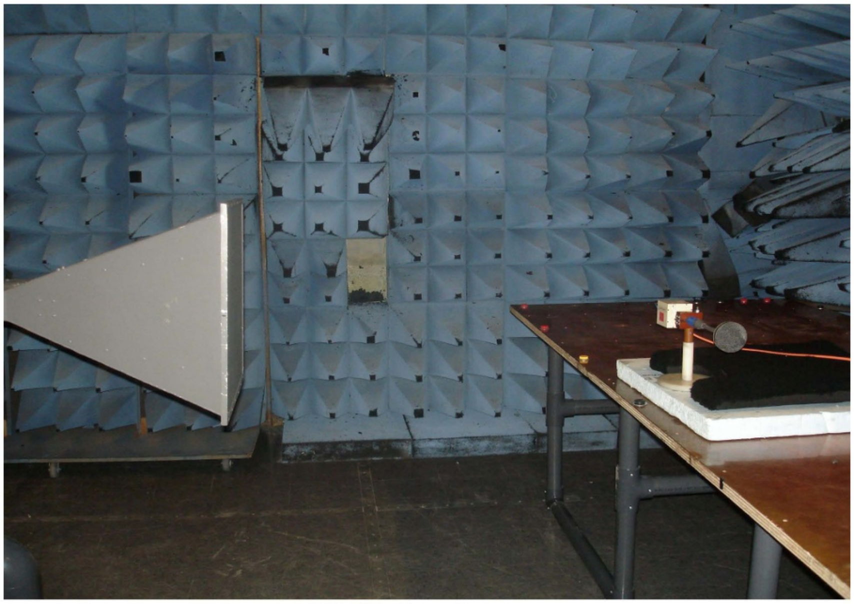
8.2.10 RS103, Test Setup Photographs


RS103, E-Field Generator

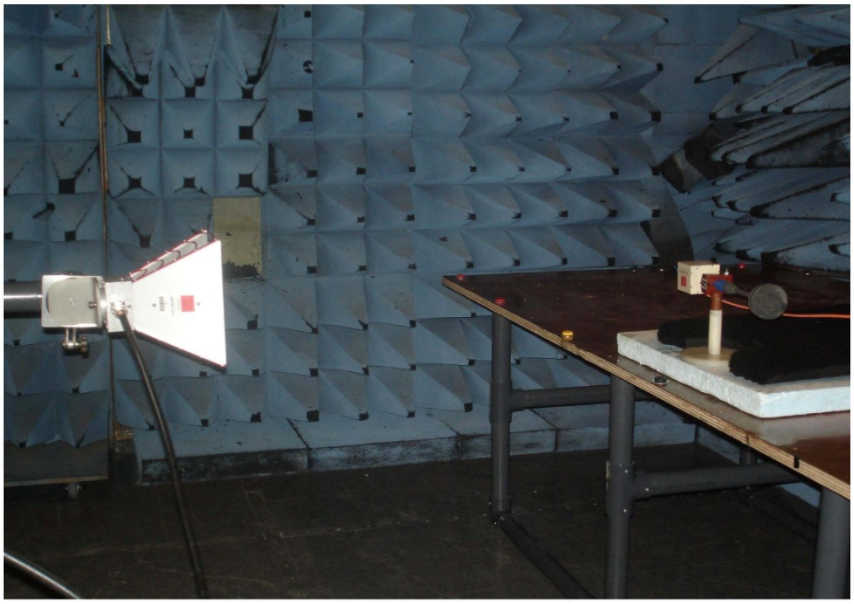

RS103, Biconical Antenna



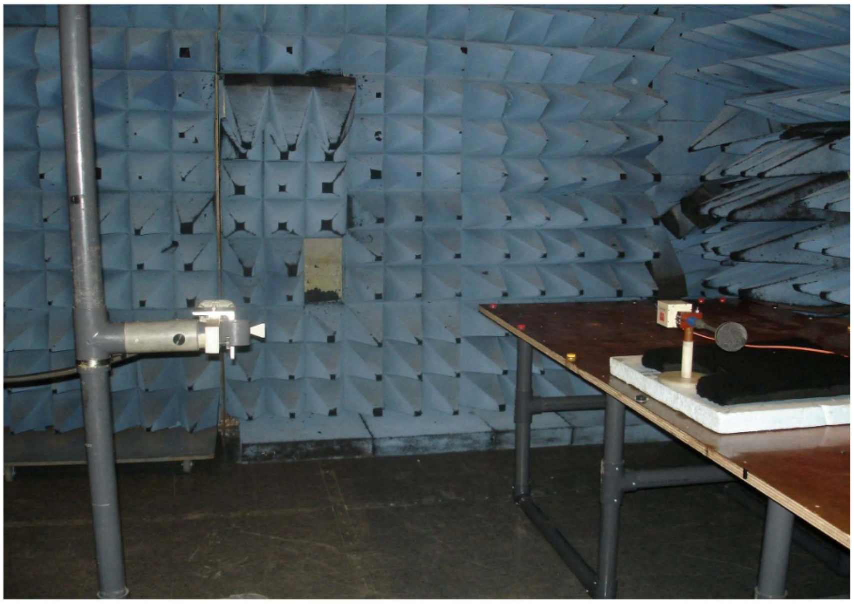
RS103, Double Ridge Waveguide Antenna



RS103, Horn Antenna



RS103, Double Ridge Waveguide Antenna



RS103, Horn Antenna

9.0 Material Evaluation Report

electro-tech systems, inc. www.electrotechsystems.com
3101 Mt. Carmel Avenue, Glenside, PA 19038 • Tel: (215) 887-2196 • Fax: (215) 887-0131

MATERIAL EVALUATION REPORT

SURFACE RESISTIVITY TESTING OF FABRIC SEAT CUSHION SAMPLES PER AATCC 76

DAYTON T. BROWN

MAY 5, 2009

Electrostatic Instrumentation • ESD Testing Laboratory • Environmental Control

MATERIAL EVALUATION REPORT
Surface Resistivity Testing of Fabric Seat Cushion Samples
Dayton T. Brown
May 5, 2009

GENERAL

Electrostatic characterization tests were performed by ETS Testing Laboratories on samples submitted by Dayton T. Brown under Purchase Order Number 097481. The samples were tested for surface resistivity per test method AATCC 76.

TEST CONDITIONS

Date of Test:	5/5/09
Humidity:	12.1% RH
Temperature:	72°F
Conditioning Time:	89 Hours

TEST APPARATUS

HUMIDITY CONTROL

An ETS Series 5000 Controlled Environment Room is used to condition and test the samples at the specified conditions. The control system utilized in the room is capable of controlling the humidity to within 1% of the desired set point with an accuracy of ±2% R.H. and temperature to within ±2°C.

SURFACE RESISTIVITY

Surface resistivity and surface resistance measurements of planer material are performed using a Dr. Thiedig Milli-TO-2 Wide Range Resistance Meter in conjunction with an ETS Model 803B Surface/Volume Resistivity Probe. An ETS Model 809B Calibration Check Fixture is used to verify the calibration of the resistance test set-up.

TEST METHODS

The following test methods and specifications were used in the evaluation of the test material:

Surface resistivity per ASTM-D 257 has generally been the property used to describe the conductive, dissipative or insulative range of static control material. The ETS Series 800 probes conform to the concentric ring design specified. The ratio between the inner and outer electrodes results in a surface resistivity equal to 10X the measured resistance. It should be noted that surface resistivity is expressed in ohms per square, without regard to the size of the square.

Surface resistance per ESD S11.11 is used to evaluate static dissipative material. This resistance is equal to the actual resistance measured with the Model 803B Probe. A test voltage of 10 volts is specified for resistances between 10^4 and 10^6 ohms. A test voltage of 100 volts is required for resistances between 10^6 and 10^{11} ohms. Surface resistance is expressed in ohms. Resistance measurements below or above these values may require different test voltages. Conductive materials (those materials with surface resistances below 10^4 ohms) are measured using either a current source (cs) or voltages equal to or less than 10 volts.

Test Method AATCC 76 measures the surface resistivity of fabric samples using the procedures defined above. When using a concentric ring probe such as the ETS Model 803B, three measurements are taken on both surfaces of each supplied material type. Pass/Fail limits are not given by this test method but are left up to the end user to determine if a material is acceptable for a specific application.

TEST RESULTS

The actual data taken is contained in the enclosed data sheets.

GROUP	MIN	MAX	AVERAGE (Ohms/Sq.)
A) Sample 25	1.12×10^{14} Ω/sq.	1.00×10^{15} Ω/sq.	4.38×10^{14} Ω/sq.
a) Sample 25 Reverse	1.11×10^{11} Ω/sq.	4.16×10^{12} Ω/sq.	2.80×10^{12} Ω/sq.
B) Sample 103926	1.01×10^{14} Ω/sq.	2.93×10^{14} Ω/sq.	1.94×10^{14} Ω/sq.
b) Sample 103926 Reverse	1.03×10^{13} Ω/sq.	4.07×10^{13} Ω/sq.	2.99×10^{13} Ω/sq.

Testing was performed using test voltages of 100 and 500 volts.

CONCLUSIONS

Resistance measurements are used in the static control industry to help categorize materials. Although resistance and resistivity measurements alone cannot tell everything about a material's electrostatic performance, it is a good indicator, can help to establish a baseline, indicate differences between additives or additive levels, show differences within a sample group and characterize the effects of relative humidity on a material's performance. Depending on the specification referenced and the composition of the material, either surface resistivity or surface resistance (or both) may be applicable.

According to industry packaging material specifications such as ESD S.541 (formerly EIA-541) and Mil-PRF-81705D which both utilize test method ASTM-D-257 at 12% R.H., a material with surface resistivity measurements less than 1×10^5 ohms/sq. is considered conductive, between 1×10^5 and 1×10^{12} ohms/sq. is considered dissipative and readings above 1×10^{12} ohms/sq. classify the material as insulative. NFPA 99, which uses test method ASTM-D-257, has an upper acceptance limit of 1×10^{11} Ω/sq at 50% R.H. Materials with resistivity measurements below this limit are considered acceptable.

Pass/Fail limits are not given by this test method but are left up to the end user to determine if a material is acceptable for a specific application.

REVIEWING YOUR DATA SHEETS

HEADER
Lists the purchase order, sample description, test conditions, date of test and the equipment used.

TEST RESULTS
Lists the individual measurements taken on each sample along with the polarity of the test voltage.

DATA ANALYSIS OF INDIVIDUAL SAMPLES
Average, standard deviation, range, minimum & maximum analysis for individual samples.

DATA ANALYSIS OF GROUPS
Average, standard deviation, range, minimum & maximum for each group of specimens giving the customer an overview of the performance of a group. This section is useful in providing information on specification compliance, group uniformity, etc.

AVERAGE
The mean value of all readings. The readings are summed and divided by the total number of data points.

MINIMUM
The lowest reading obtained in a sample group.

MAXIMUM
The highest reading obtained in a sample group.

Dayton T Brown, Inc.

P.O.# 097481 Surface Resistance/Resistivity Testing of Seat Cover

Date in Chamber	: 05/01/09	Date Tested	: 05/05/09
Time in Chamber	: 16:00	Time Tested	: 09:00
Ambient Humidity	: 50.1% R.H.	Test Humidity	: 12.1% R.H.
Ambient Temperature	: 72°F	Test Temperature	: 72°F
Hours Conditioned	: 89 hours		
Meter Type	: Dr. Theidig Milli TO-2		
Probe Type	: ETS Model 803B		
Calibration Fixture	: ETS Model 809B (5.00 $\times 10^{5}$ ohms)		

Test Results

Sample	Ve	Surface Resistance Ohms	Surface Resistivity Ohms/Square
Calibration	10	5.05×10^{5}	
Group A:			
#25-1	500	1.00×10^{14}	1.00×10^{15}
#25-2	500	2.02×10^{13}	2.02×10^{14}
#25-3	500	1.12×10^{13}	1.12×10^{14}
Group a:			
Rev. #25-1	100	4.13×10^{11}	4.13×10^{12}
Rev. #25-2	100	1.11×10^{10}	1.11×10^{11}
Rev. #25-3	100	4.16×10^{11}	4.16×10^{12}
Group B:			
103926-1	500	1.87×10^{13}	1.87×10^{14}
103926-2	500	2.93×10^{13}	2.93×10^{14}
103926-3	500	1.01×10^{13}	1.01×10^{14}
Group b:			
R-103926-1	500	4.07×10^{12}	4.07×10^{13}
R-103926-2	500	1.03×10^{12}	1.03×10^{13}
R-103926-3	500	3.88×10^{12}	3.88×10^{13}

Data Analysis

	Surface Resistance			Surface Resistivity		
	Min	Avg	Max	Min	Avg	Max
A	1.12×10^{13}	4.38×10^{13}	1.00×10^{14}	1.12×10^{14}	4.38×10^{14}	1.00×10^{15}
a	1.11×10^{10}	2.80×10^{11}	4.16×10^{11}	1.11×10^{11}	2.80×10^{12}	4.16×10^{12}
B	1.01×10^{13}	1.94×10^{13}	2.93×10^{13}	1.01×10^{14}	1.94×10^{14}	2.93×10^{14}
b	1.03×10^{12}	2.99×10^{12}	4.07×10^{12}	1.03×10^{13}	2.99×10^{13}	4.07×10^{13}

APPENDIX G: Flammability Results

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received: 03/10/2009	Completed: 03/20/2009	Letter: A	rb	P.O.#:	Test Report #: 2-77628-0-
Client's Identification	Style A. Style: Goodrich Air Bladder Ejection Seat Cushion. Composition: Foam and Air Bladders with Sheepskin Cover. End Use: Ejection Seat Cushion. [Component Tested: Sheepskin Cover]				

Tested For: **Steve Bredl**
Goodrich AIP
1275 N. Newport Road
Colorado Springs, CO 80916

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(719)-380-0020 **Ext:**
Fax: 1-(719)-380-0040

Test Category: 12sec Vertical/Textiles Specifier: FAA PC: 24H

TEST PERFORMED: Vertical Test (12 seconds flame application) as per FAR Part 25, Appendix F, Part I(b)(4)

RESULTS ARE REPORTED: [x] Initially; [ ] After laundering; [ ] After dry cleaning

PRODUCT CATEGORY: Textiles

REFERENCE: For Certain Textile Products Used in Compartment Interiors Transport Category, Airplanes: FAR 25.853(a) and Appendix F Part I(a)(1)(ii) [previously FAR 25.853(b)]

RESULTS:

	Specimen #	Afterflame (seconds)	Drip Burn (seconds)	Burn Length (inches)	Melt Length* (inches)
Machine:	1	0	0	4.0	0
	2	0	0	3.7	0
	3	0	0	4.0	0
	Avg	0	0	3.9	
Cross Machine:	4	NA	NA	NA	NA
	5	NA	NA	NA	NA
	6	NA	NA	NA	NA
	Avg				

* NOTE: IN CERTAIN INSTANCES A PORTION OF THE MATERIAL UNDER TEST WILL BE DAMAGED BY THE BURNING PROCESS AND A FURTHER DEGRADATION WILL BE ATTRIBUTABLE TO SHRINKAGE OR MELTING AWAY FROM THE IGNITING FLAME. THE ACTUAL DAMAGED DISTANCE ATTRIBUTABLE TO BURNING IS ENTERED IN THE "BURN LENGTH" COLUMN. THE MELTED/SHRINKAGE DISTANCE IS ENTERED IN THE "MELT LENGTH" COLUMN.

CONCLUSION: Based on the above Results and the Acceptance Criteria on page 2, the item tested:

[x] Complies; [ ] Does not comply

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received: 03/10/2009	**Completed:** 03/20/2009	**Letter:** A	rb	**P.O.#:**	**Test Report #:**	2-77628-0-

Client's Identification	Style A. Style: Goodrich Air Bladder Ejection Seat Cushion. Composition: Foam and Air Bladders with Sheepskin Cover. End Use: Ejection Seat Cushion. [Component Tested: Sheepskin Cover]

Tested For: Steve Bredl
Goodrich AIP
1275 N. Newport Road
Colorado Springs, CO 80916

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(719)-380-0020 **Ext:**
Fax: 1-(719)-380-0040

REMARKS: NA = Not Available

ACCEPTANCE CRITERIA:

Afterflame - 15.0 seconds maximum average
Drip Burn - 5.0 seconds maximum average
Burn Length - 8.0" maximum average

Note: Melt Length, when observed, is reported; however, it is not factored into the Acceptance Criteria.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified by Code of Federal Regulations Title 14 Part 25, revised as of January 1, 2008.

MR. ROBERT I. BROWN MAR 2 [illegible]

GOOD/INFO

AUTHORIZED SIGNATURE
THE GOVMARK ORGANIZATION, INC. /jb/mg

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

eceived: 03/10/2009	Completed: 03/20/2009	Letter: B	rb	P.O.#:	Test Report #: 2-77629-0-

lient's dentification Style B. Style: U.S. Air Force Baseline Ejection Seat Cushion. Composition: Foam with Sheepskin Cover. End Use: Ejection Seat Cushion. [Component Tested: Sheepskin Cover]

ested For: Scott Fleming
U.S. Air Force
2800 Q Street, Bldg. 824
Wright Patterson AFB, OH 45433

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(937)-572-5015 **Ext:**
Fax: 1-(937)-656-7110

est Category: 12sec Vertical/Textiles Specifier: FAA PC: 24H

EST PERFORMED: Vertical Test (12 seconds flame application) as per FAR Part 25, Appendix F, Part (b)(4)

ESULTS ARE REPORTED: [x] Initially; [ ] After laundering; [ ] After dry cleaning

RODUCT CATEGORY: Textiles

EFERENCE: For Certain Textile Products Used in Compartment Interiors Transport Category, Airplanes: AR 25.853(a) and Appendix F Part I(a)(1)(ii) [previously FAR 25.853(b)]

ESULTS:

	Specimen #	Afterflame (seconds)	Drip Burn (seconds)	Burn Length (inches)	Melt Length* (inches)
Machine:	1	7.0	0	3.0	0
	2	3.8	0	3.4	0
	3	1.2	0	3.6	0
	Avg	4.0	0	3.3	
Cross Machine:	4	NA	NA	NA	NA
	5	NA	NA	NA	NA
	6	NA	NA	NA	NA
	Avg				

NOTE: IN CERTAIN INSTANCES A PORTION OF THE MATERIAL UNDER TEST WILL BE DAMAGED BY THE BURNING OCESS AND A FURTHER DEGRADATION WILL BE ATTRIBUTABLE TO SHRINKAGE OR MELTING AWAY FROM THE IGNITING AME. THE ACTUAL DAMAGED DISTANCE ATTRIBUTABLE TO BURNING IS ENTERED IN THE "BURN LENGTH" COLUMN. THE LTED/SHRINKAGE DISTANCE IS ENTERED IN THE "MELT LENGTH" COLUMN.

NCLUSION: Based on the above Results and the Acceptance Criteria on page 2, the item tested:

[x] Complies; [ ] Does not comply

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received: 03/10/2009	Completed: 03/20/2009	Letter: B	rb	P.O.#:	Test Report #: 2-77629-0-

Client's Identification	Style B. Style: U.S. Air Force Baseline Ejection Seat Cushion. Composition: Foam with Sheepskin Cover. End Use: Ejection Seat Cushion. [Component Tested: Sheepskin Cover]

Tested For:	**Scott Fleming**	Key Test:	FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
	U.S. Air Force		
	2800 Q Street, Bldg. 824	Tel:	1-(937)-572-5015 Ext:
	Wright Patterson AFB, OH 45433	Fax:	1-(937)-656-7110

REMARKS: NA = Not available.

ACCEPTANCE CRITERIA:

Afterflame - 15.0 seconds maximum average
Drip Burn - 5.0 seconds maximum average
Burn Length - 8.0" maximum average

Note: Melt Length, when observed, is reported; however, it is not factored into the Acceptance Criteria.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified by Code of Federal Regulations Title 14 Part 25, revised as of January 1, 2008.

MR. ROBERT I. BROWN MAR 2

AUTHORIZED SIGNATURE
THE GOVMARK ORGANIZATION, INC. /jb/mg USAF/INFO

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received:03/10/2009	Completed:03/20/2009	Letter: C	rb	P.O.#:	Test Report #: 2-77630-0-
Client's Identification	Style C. Style: Oregon Aero Ejection Seat Cushion. Composition: Foam with Sheepskin Cover. End Use: Ejection Seat Cushion. [Component Tested: Sheepskin Cover]				

Tested For: **Tony Erickson**
Oregon Aero, Inc.
34020 Skyway Drive
Scappoose, OR 97056-2516

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(503)-543-7399 **Ext:**
Fax: 1-(503)-543-7199

Test Category: 12sec Vertical/Textiles Specifier: FAA PC: 24H

TEST PERFORMED: Vertical Test (12 seconds flame application) as per FAR Part 25, Appendix F, Part I(b)(4)

RESULTS ARE REPORTED: [x] Initially; [ ] After laundering; [ ] After dry cleaning

PRODUCT CATEGORY: Textiles

REFERENCE: For Certain Textile Products Used in Compartment Interiors Transport Category, Airplanes: FAR 25.853(a) and Appendix F Part I(a)(1)(ii) [previously FAR 25.853(b)]

RESULTS:

	Specimen #	Afterflame (seconds)	Drip Burn (seconds)	Burn Length (inches)	Melt Length* (inches)
Machine:	1	4.0	0	2.7	0
	2	4.8	0	3.0	0
	3	4.0	0	3.5	0
	Avg	4.3	0	3.1	
Cross Machine:	4	NA	NA	NA	NA
	5	NA	NA	NA	NA
	6	NA	NA	NA	NA
	Avg				

* NOTE: IN CERTAIN INSTANCES A PORTION OF THE MATERIAL UNDER TEST WILL BE DAMAGED BY THE BURNING PROCESS AND A FURTHER DEGRADATION WILL BE ATTRIBUTABLE TO SHRINKAGE OR MELTING AWAY FROM THE IGNITING FLAME. THE ACTUAL DAMAGED DISTANCE ATTRIBUTABLE TO BURNING IS ENTERED IN THE "BURN LENGTH" COLUMN. THE MELTED/SHRINKAGE DISTANCE IS ENTERED IN THE "MELT LENGTH" COLUMN.

CONCLUSION: Based on the above Results and the Acceptance Criteria on page 2, the item tested:

[x] Complies; [ ] Does not comply

File Copy

The Govmark Organization, Inc.
96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received: 03/10/2009	Completed: 03/20/2009	Letter: C	rb	P.O.#:	Test Report #:	2-77630-0-

Client's Identification	Style C. Style: Oregon Aero Ejection Seat Cushion. Composition: Foam with Sheepskin Cover. End Use: Ejection Seat Cushion. [Component Tested: Sheepskin Cover]

Tested For: **Tony Erickson**
Oregon Aero, Inc.
34020 Skyway Drive
Scappoose, OR 97056-2516

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(503)-543-7399 **Ext:**
Fax: 1-(503)-543-7199

REMARKS: NA = Not Available

ACCEPTANCE CRITERIA:

Afterflame - 15.0 seconds maximum average
Drip Burn - 5.0 seconds maximum average
Burn Length - 8.0" maximum average

Note: Melt Length, when observed, is reported; however, it is not factored into the Acceptance Criteria.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified by Code of Federal Regulations Title 14 Part 25, revised as of January 1, 2008.

MR. ROBERT L. BROWN

AUTHORIZED SIGNATURE
THE GOVMARK ORGANIZATION, INC. /jb/mg

ORE/INFO

(Page 2 of 2)

The results contained in this report relate only to item(s) tested. The test report shall not be reproduced, except in full, without written approval from The Govmark Organization, Inc.

File Copy

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received: 03/10/2009	Completed: 03/20/2009	Letter: D	rb	P.O.#:	Test Report #: 2-77631-0-

Client's Identification	Style D. Style: Oregon Aero Ejection Seat Cushion. Composition: Foam with Cloth Cover. End Use: Ejection Seat Cushion. [Component Tested: Cloth Cover]

Tested For: **Tony Erickson**
Oregon Aero, Inc.
34020 Skyway Drive
Scappoose, OR 97056-2516

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(503)-543-7399 **Ext:**
Fax: 1-(503)-543-7199

Test Category: 12sec Vertical/Textiles Specifier: FAA PC: 24H

TEST PERFORMED: Vertical Test (12 seconds flame application) as per FAR Part 25, Appendix F, Part I(b)(4)

RESULTS ARE REPORTED: [x] Initially; [ ] After laundering; [ ] After dry cleaning

PRODUCT CATEGORY: Textiles

REFERENCE: For Certain Textile Products Used in Compartment Interiors Transport Category, Airplanes: FAR 25.853(a) and Appendix F Part I(a)(1)(ii) [previously FAR 25.853(b)]

RESULTS:

	Specimen #	Afterflame (seconds)	Drip Burn (seconds)	Burn Length (inches)	Melt Length* (inches)
Machine:	1	35.2	1.0	2.6	0
	2	9.9	1.0	2.7	0
	3	19.4	0.0	3.2	0
	Avg	(21.5)	0.7	2.8	
Cross Machine:	4	7.0	2.0	2.6	0
	5	13.0	1.0	2.8	0
	6	18.0	1.0	2.5	0
	Avg	12.9	1.3	2.6	

* NOTE: IN CERTAIN INSTANCES A PORTION OF THE MATERIAL UNDER TEST WILL BE DAMAGED BY THE BURNING PROCESS AND A FURTHER DEGRADATION WILL BE ATTRIBUTABLE TO SHRINKAGE OR MELTING AWAY FROM THE IGNITING FLAME. THE ACTUAL DAMAGED DISTANCE ATTRIBUTABLE TO BURNING IS ENTERED IN THE "BURN LENGTH" COLUMN. THE MELTED/SHRINKAGE DISTANCE IS ENTERED IN THE "MELT LENGTH" COLUMN.

CONCLUSION: Based on the above Results and the Acceptance Criteria on page 2, the item tested:

[ ] Complies; [x] Does not comply

File Copy

The Govmark Organization, Inc.

96-D Allen Boulevard
Farmingdale, New York 11735-5626 USA
Tel. +1 (631) 293-8944 Fax +1 (631) 293-8956
e-mail: info@govmark.com

Received: 03/10/2009	Completed: 03/20/2009	Letter: D	rb	P.O.#:	Test Report #:	2-77631-0-
Client's Identification	Style D. Style: Oregon Aero Ejection Seat Cushion. Composition: Foam with Cloth Cover. End Use: Ejection Seat Cushion. [Component Tested: Cloth Cover]					

Tested For: Tony Erickson
Oregon Aero, Inc.
34020 Skyway Drive
Scappoose, OR 97056-2516

Key Test: FAA 12-sec. Vert FAR 25.853(a) (Textiles) 105
Tel: 1-(503)-543-7399 **Ext:**
Fax: 1-(503)-543-7199

REMARKS: None.

ACCEPTANCE CRITERIA:

Afterflame - 15.0 seconds maximum average
Drip Burn - 5.0 seconds maximum average
Burn Length - 8.0" maximum average

Note: Melt Length, when observed, is reported; however, it is not factored into the Acceptance Criteria.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified by Code of Federal Regulations Title 14 Part 25, revised as of January 1, 2008.

MR. ROBERT L BROWN

AUTHORIZED SIGNATURE
THE GOVMARK ORGANIZATION, INC. /jb/mg

ORE/INFO

APPENDIX H: Safety Assessment Report

HAZARD: Pilot hits the ground or another aircraft (CFIT or Midair) because he is distracted by the operation or malfunction of the seat cushion
Cause: The cushion is a distraction to the pilot during flight due to a malfunction or normal operation. Examples of malfunctions include an air leak, bladder “pop”, or a dead battery.
Effect: Pilot may become distracted during flight due to increased cognitive load.
Minimizing Procedures: Seat cushions will be thoroughly tested on the ground prior to flight to determine any defects. Pilots will be trained in normal operation of the cushion. The cushion has been flight tested at the AFFTC in F-16 aircraft. Altitude tests were conducted according to Mil-STD-810F. The cushion successfully functioned during the altitude testing. Post-test, the cushion required a reset. This is most likely due to a now-fixed flaw in the cushion.
Initial HRI: IE
Final HRI:

HAZARD: Pilot hits the ground or another aircraft (CFIT or Midair) due to discomfort of buttocks
Cause: The cushion becomes uncomfortable to the pilot during a long duration mission.
Effect: Discomfort could cause increased cognitive load, causing the pilot to become distracted during flight and increasing the probability of error.
Minimizing Procedures: The cushion has been tested in both 8hr and 4hr comfort testing. The cushion has been used in 24 hr flight simulations with positive feedback in how comfortable the cushion is compared to the standard ACES II cushion.
Initial HRI: IE
Final HRI:

HAZARD: The cushion detaches from seat pan and becomes an unrestrained projectile in the cockpit
Cause: The cushion does not fit or attach the same as the standard ACES II cushion to the seat pan.
Effect: The cushion will detach from the seat pan and become an unrestrained projectile in the cockpit.
Minimizing Procedures: The cushion attaches to the seat pan in the same way as the standard ACES II cushion. The snaps and loops are exactly the same as the standard cushion.
Initial HRI: IIIE
Final HRI:

HAZARD: The pilot’s effectiveness is affected due to changing of the sitting height during inflating/deflating of the cushion
Cause: The sitting height of the cushion changes due to inflating/deflating of the air bladder cushion.
Effect: the cushion puts the pilot out of the design eye. The pilot cannot
Minimizing Procedures: The change in sitting heights compared to the standard cushion have been recorded. The cushion is ‘thicker’ than the standard cushion, though the changes are rectified through shifting of the pilot while sitting. Design eye height not noticeably changed for F-16 test pilots at AFFTC.
Initial HRI:

HAZARD: The pilot is at increased risk during a birdstrike due to increased thickness of the seat cushion in F-16 aircraft
Cause: The sitting height of the cushion is higher than the standard ACES II cushion.
Effect: the pilot's head is further put in the birdstrike region of the canopy in constrained aircraft such as the F-16.
Minimizing Procedures:
Initial HRI:IE

HAZARD: Probability of neck/back injury during ejection is increased compared to standard ACES II seat cushion
Cause: Change in cushion could increase lumbar loading during ejection.
Effect: Pilot has increased risk of back injury during ejection.
Minimizing Procedures: AFRL performed several full series of testing on their Vertical Deceleration Tower (VDT) at Wright-Patt AFB. Lumbar loads are below established lumbar load injury criteria and comparable to the standard ACES II cushion for small, medium, and large occupants. The cushion was also tested during multiple ejection sled tests. Measured lumbar loads were consistent the standard ACES II seat cushion.
Initial HRI: IE

HAZARD: The cushion electronics catch fire during flight, requiring ejection from aircraft
Cause: The AFRL cushion introduces additional electronics in the cockpit including batteries.
Effect: The cushion or batteries catch fire during flight. The pilot could be severely burned and require ejection from the aircraft.
Minimizing Procedures: The cushion has been tested up to 160 degrees Fahrenheit, according to Mil-Std-810F, with no issue. Operating temperatures of the cushion is well within the temperature limits of the batteries according to the battery data sheet.
HRI: IE

HAZARD: The pilot is subjected to toxic fumes if the cushion catches fire
Cause: The cushion catches fire during flight, releasing toxic fumes inhaled by the pilot.
Effect: The pilot has increased risk of lung injury. This could cause the pilot loss of consciousness and ultimate ground collision.
Minimizing Procedures: A toxicity test was conducted according to Boeing Test Method BSS 7239. The results do not exceed the suggested maximum values of combustion products.
HRI: IE

HAZARD: Pilot visibility lessened in cockpit due to smoke generation from cushion fire
Cause: The cushion catches fire during flight, releasing smoke impairing the pilot's sight.
Effect: The pilot loses situational awareness and is forced to ejection from aircraft.
Minimizing Procedures: Smoke generation tests were conducted according to Boeing Test Method BSS 7238. The cushion passed the test while the standard ACES II cushion does not. Flammability tests were conducted according to FAA Fire Block FAR 25.853(c). The cushion did not pass the flammability tests. Fire in the cockpit would require egress from the cabin, thus it is a non-issue.
HRI: IE

HAZARD: Aircraft electronics are affected due to added electronics added in cockpit

Cause: The AFRL cushion includes electronics for the bladder to inflate/deflate. These electronics could affect the operation of aircraft electronics due to electromagnetic waves.

Effect: Aircraft electronics will not work properly.

Minimizing Procedures: EMI emissions testing was conducted according to MIL-STD-461E, method RE102. The cushion passed EMI emissions testing. In addition, a successful EMI check was conducted in an F-16 at AFFTC to ensure it did not affect aircraft systems. Surface Resistivity testing was conducted according to MIL-STD-461E, method AATCC76. The cushion did not pass this testing, the cushion cover is the same as that of the standard ACES II cushion.

Initial HRI: IIE

HAZARD: Pilot is distracted or grows fatigued due to increased vibration in the cockpit

Cause: The AFRL cushion changes the vibration signature of the aircraft transmitted to the pilot during flight.

Effect: The pilot may become distracted or have increased fatigue during flight resulting in increased cognitive and physical load.

Minimizing Procedures: A study was conducted to compare the biodynamic, subjective comfort, and occupant performance effects of selected prototype seat pan cushions vs the standard seat pan cushion used in high performance military jets during exposure to low levels of vibration. One of the prototype cushions employed a pulsating air bladder system. The second prototype cushion was contoured and layered with rate-sensitive foam. The standard cushion was a relatively thin flat cushion that included rate-sensitive foam. Level flight vertical axis (Z) vibration accelerations collected on the F-15 were recreated in the 711 HPW/RHPA human-rated single-axis vibration facility. Subjects performed a multi-attribute performance task during 30-minute exposures to the vibration while seated on either a prototype cushion or the standard cushion. Following the exposure, the subjects responded to a subjective seat comfort questionnaire. In addition, the subjects were also exposed to a flat acceleration spectrum for evaluating the transmissibility characteristics of the tested seat cushion at the occupant/seat interface. Following a short rest period of approximately 5 minutes, during which time the cushion was replaced with either the prototype or standard, the subjects were again exposed to the low frequency vibration for 30 minutes and the process was repeated. Three sets of repetitions were performed for each prototype on separate days, and included switching the order of the cushion testing.

Although the data are currently being analyzed, the preliminary results suggest that the subjective comfort ratings among the cushions were similar and that minimal differences were observed in the performance tasks for the short duration exposures used in this study (30 minutes). However, the transmissibility data do strongly suggest differences among the cushions, particularly between the two prototypes tested and the standard cushion. Both prototypes showed significantly higher transmissibility between about 4.5 and 5 Hz as compared to the standard cushion with means of approximately 1.30 – 1.4 for the air bladder cushion, 1.25 – 1.3 for the contoured cushion, and 1.0 for the standard cushion. In contrast, both prototypes showed greater dampening (transmissibility < 1) beyond about 6 Hz as compared to the standard cushion. The greatest dampening was observed with the air bladder cushion. All cushions showed mean transmissibilities below 1 around 8.5 – 9.0 Hz, where a resonance peak was

observed in the F-15 acceleration spectra entering the seating system. This peak was associated with structural characteristics of the F-15. While the vibration at this resonance can be substantial in this aircraft during high angle of attach maneuvers, the levels appear to be quite low during level flight. For other jet aircraft, it is assumed that any vibration generated by the vehicle occurs primarily in the Z axis at higher frequencies beyond 20 Hz. The only exception may include any substantial air turbulence that could cause low frequency vibration below 10 Hz. Otherwise, the two tested prototype cushions present similar or less vertical axis vibration transmission as compared to the standard jet aircraft cushion.
HRI: IIIE

DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433-7008

23 March 2015

MEMORANDUM FOR DTIC-CQ
8725 JOHN J. KINGMAN ROAD
FORT BELVOIR, VA 22060-6218

FROM: 711 HPW/OMCA (STINFO)
2947 Fifth Street
Wright-Patterson AFB, OH 45433-7913

SUBJECT: Request to Change the Distribution Statement on a Technical Report

This memo documents the requirement for DTIC to change the distribution statement on the following technical report from distribution statement B to A. Approved for Public Release; distribution is unlimited.

AD Number: ADB360405
Publication number: AFRL-RH-WP-TR-2010-0083
Title: Seat Interfaces for Aircrew Performance and Safety

Reason for request: The current Distribution B limits release of the results of this study to US Gov Agencies Only. The study tested new advanced prototype aircraft seat cushion technologies as well as existing seat cushions for comfort, safety, and environmental exposures. The prototype seat cushions were developed and tested to a draft specification to deliver increased comfort and performance to Airmen in confined environments while maintaining safety. The range of testing methodologies and the different types of experimental and operational cushions make this study of high value to other DoD agencies and cushion designers interested in applying these new technologies to enhance current seat cushion designs. Changing the report to Distribution A will have the benefit of making sure these technologies are available and can be implemented in any new seat cushion designs to help ensure crewmember safety and performance.

Donald Denio

DONALD DENIO
STINFO Officer
711th Human Performance Wing